Faculdade de Design,
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AN ECOSYSTEM FOR SMART MOBILITY: BUS AS A CASE STUDY

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Dissertação apresentada ao IADE - Faculdade de Design, Tecnologia e Comunicação da Universidade Europeia, para cumprimento dos requisitos necessários à obtenção do grau de Mestre em Design de Interação realizada sob a orientação científica da Doutora Hande Ayanoglu Vangolde, Professora Auxiliar no IADE- Faculdade de Design Tecnologia e Comunicação da Universidade Europeia e do Doutor Bruno Miguel Correia Silva, Professor Auxiliar na Universidade da Beira Interior e Investigador no Instituto de Telecomunicações.

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palavras-chave

Lisboa, Sustentabilidade, UX Design, Autocarro Inteligente, Paragem de autocarro inteligente.

resumo

Nas cidades de hoje em dia, como Lisboa, em Portugal, existem problemas de mobilidade. Nas cidades, especialmente, dos países em desenvolvimento, não existem medidas adequadas para lidar com o aumento dos meios de transporte particulares que congestionam o trânsito. A grande maioria dos veículos é movida a combustíveis fósseis o que leva a um impacto negativo na sustentabilidade ambiental, mais especificamente na poluição do ar e o aquecimento global. Devido a estes problemas é essencial que os cidadãos utilizem transportes públicos coletivos, deixando a questão: Porque é que não os utilizam? A maioria dos cidadãos afirma que o transporte individual é mais rápido e confortável, relatando ainda mais problemas relacionados com os transportes públicos. Com a ajuda do UX design é possível criar uma solução interativa que propõe a conexão entre o utilizador, a paragem de autocarro e o autocarro. Com esta aplicação é possível dar conforto e rapidez ao utilizador enquanto utiliza a mesma. Para a avaliação da usabilidade desta aplicação foi necessário realizar vários testes com o propósito de incentivar os cidadãos a utilizarem mais os transportes públicos melhorando a sua satisfação. Para a criação e desenvolvimento deste ecossistema foi utilizada a metodologia UCD aplicada em vários testes. O primeiro teste foi a realização de um questionário com intuito de identificar os problemas dos autocarros e recolher dados sociodemográficos que levaram à criação do target e, consequentemente, à criação das personas e das suas jornas de utilizador. A avaliação do ecossistema começou com o teste do *card sorting* para ajudar a entender a hierarquia de informação que se revelou com resultados positivos, permitindo o progresso do estudo para a realização de um teste moderado ao protótipo de baixa fidelidade que mostrou os erros de usabilidade que foram encontrados pelos participantes, que de seguida, foram corrigidos para a realização do último teste. A análise de heurísticas não moderada serviu para que os participantes profissionais na área revelassem os erros que ainda não tinham sido descobertos. Em conclusão esta tese contribui para o melhoramento da utilização diária dos transportes públicos através de um ecossistema amigo do utilizador que criou duas interfaces.

Keywords

Lisbon, Sustainability, UX Design, Smart Bus, Smart Bus Shelter

abstract

In today's cities like Lisbon, Portugal, there are mobility problems particularly with transportation in the city. In cities, especially in developing countries, there are no adequate measures to deal with the growing number of motor vehicles, causing traffic congestion. The overwhelming majority of vehicles are fueled by fossil fuels that have very negative impacts on sustainability, more specifically on-air pollution and global warming. Due to these problems, it is essential to make citizens to use public transportation, leaving the question why don't they use it? The majority of the population claims that individual transportation is more comfortable and even quicker, among other problems related with public transportation. With the help of the UX design it is possible to create an interactive solution which proposes the connection between the user, the smart bus shelter and the smart bus. With the application, it is possible to give comfort and quickness to the users while using the bus. For the creation and development of this ecosystem was used the UCD methodology applied to several tests. The first one was a questionnaire to identify the problems in buses and gather sociodemographic data to build the target and consequently the personas and their user journey. The evaluation of the ecosystem started with the card sorting to help understand the hierarchy of the information which showed positive results allowing the study to progress to the moderated test of the low fidelity prototype that showed the errors encountered by the participants which were corrected to the last test was an unmoderated Heuristic Analysis to have feedback from experts and correct the mistakes that were revealed. In conclusion this thesis contributes to improving the daily usage of the public transportation throughout a user-friendly ecosystem that created two different interfaces.

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1. Introduction

1.1. Problem definition

The Smart city is a vision that have been growing for urban development that aggregates a lot of divisions of society with the help of the Internet of Things (IoT). The intention is to link and administrate a city's assets associated to multiple areas. This concept is born out of the hyper-globalization and the epidemic innovation in the technological department. With these changes it is necessary to update the cities to a smart living with smart surroundings that can promote a better life for its citizens (Mahmood, 2017). It can be said that the idea of a smart city is built on the interrelation between the humans, the technological infrastructure and the social capital as a way to improve the quality of life of its citizens (Eleutheriou, Depiné, Teixeira, & Azevedo, 2017).

In today's cities it is possible to consider that there is a mobility problem associated with transport in a city. In cities, especially in developing countries, there are no adequate measures to deal with the growing number of motor vehicles, causing traffic congestion, environmental and health problems, as well as the quality of public space. The overwhelming majority of vehicles are fueled by fossil fuels that have very negative impacts on sustainability, more specifically on-air pollution and global warming (Tokoro, 2016). There are currently around 25,000 fatalities on European roads and about 1.4 million road traffic injuries. Most of these accidents are due to human error, not only while driving a motor vehicle, but also due to human factors, particularly the interaction between human and technology (ERTRAC, 2019). All of these arguments leave a question: why don't citizens use public transportation instead for their personal car? According to the *Instituto Nacional de Estatística (INE)*, for 2017 data, it shows that Lisbon citizens prefer the car as a means of transport. With 62.5% of users saying that the car is faster and 50.4% say the car is more comfortable than public transport. There are still problems with these, such as: "public transport network without direct connection to destination", "lack of alternative" and "public transport service without the necessary frequency or reliability" (Marujo, 2018).

Due to these problems, it is essential to have a smart city that bets in it´s smart mobility. It is composed by a lot of features like the focus on the mobility of its people and not only on the vehicles, the advocating of walkability and cycling, its vibrating streets with no additional cost, the efficiency of managing vehicular and pedestrian traffic as well as traffic congestion, bicycle

routes, balanced transportation options, a high-speed mobility system; a system that links, work places (Kumar & Dahiya, 2017). That is, Intelligent Mobility is widely permeated by ICTs, used in earlier and later applications, to support the optimization of traffic flows, but also to gather citizens' opinions on the capacity to live in cities or the quality of public transport local services local public (Benevolo, Paola, & D'Auria, 2015). In May of 2017 IMT (Instituto da Mobilidade e dos Transportes, I.P) organized a conference where Intelligent Mobility was presented, a vision and a way, to try to resolve the current problems in mobility. This approach is based on a rebalancing of the modal split and reduction of impacts of the current motorization standard achieved through four main goals: the containment and rationalization of the use of the individual car, the promotion and dissemination of sustainable energy sources and propulsion systems, the encouragement of public transport and new mobility services and at last but not at least the increasing use of soft or active modes of transportation such as bicycle (IMT - Instituto de Mobilidade e Transportes, 2017). Talking about smart mobility we must have into account the trace of data the use of location devices that stand out: GPS (Global Positioning System), GSM (Global System for Mobile Communications), Wi-Fi, Bluetooth, and RFID (Radio Frequency Identification) (Shamalinia, 2017). Fujisawa SST aims to implement services to solve the mobility problems which a reality in most cities today, the so-called "total mobility services". In these areas it is possible to share electric bicycles, assist-bicycles, car rentals, rental of charged batteries. In this sharing service, the user selects one of all the previously mentioned vehicles to rent a car, there will be a service that delivers the car to the user's home. This service is named "Mobility Concierge". It has also the ability to advise the users of the best transport to rent, according to the distance, the hours of the day and the volume of traffic. Users can also check the status of car rental or make the rental through the television or a smartphone. Users of electric bicycles can exchange their batteries, free of charge, through exchange points around the city, as a way to encourage the use of soft transportation (Tokoro, 2016). The ERTRAC's vision to be "safe and secure at any time" includes many goals, but most the most relevant one for this paper is to have almost no traffic accidents and injuries due to the safety functions expected to be provided by automated driving functions and the connection between vehicles and infrastructure (ERTRAC, 2019). A good measure in terms of sustainability is having most of the city car-free by providing driverless electric pods that transport users, like car sharing (Santamouris & Cartalis, 2017).

All these projects and ideas regarding smart cities and smart mobility began with the Internet of things, which according to the Internet of Things Strategic Research Agenda (2015) is "A global network and service infrastructure of variable density and connectivity with self-configuring capabilities based on standard and interoperable protocols and formats which consists of heterogeneous things that have identities, physical and virtual attributes, and are seamlessly and securely integrated into the Internet." (Minerva, Biru, & Rotondi, 2015).

1.2. Motivation

Today cities are experiencing serious problems due to the excessive traffic of fossil fuel powered vehicles that directly affects the sustainability of cities and contributes to global warming, as well as the air quality that is revealed in the various climate problems health of its citizens. Due to this situation, measures need to be taken to encourage citizens to use public transportations to reduce the use of individual transport. To solve these problems there has been a growth in mobile applications developed for mobility within a city. Applications such as Moovit, Google Maps, and others have both content and usability shortcomings. All of these flaws mean that these applications do not become the right solution to the sustainability issues previously mentioned. In this research it was possible to understand that with the creation of the bus-driven mobility ecosystem, it is possible to combat various problems that exist in this mode of transport, such as frequent delays, lack of information about the location of buses and the discomfort it causes to passengers, during rush hour, from their excessive occupation. Thus, this research is born in order to create an ecosystem to improve and facilitate the use of public transport, particularly buses. The motivation of this research is to validate the implementation of a connecting ecosystem that consists of a smart bus stop, a smart bus and the users, using UX design and UI design as a resource to create a user-friendly ecosystem.

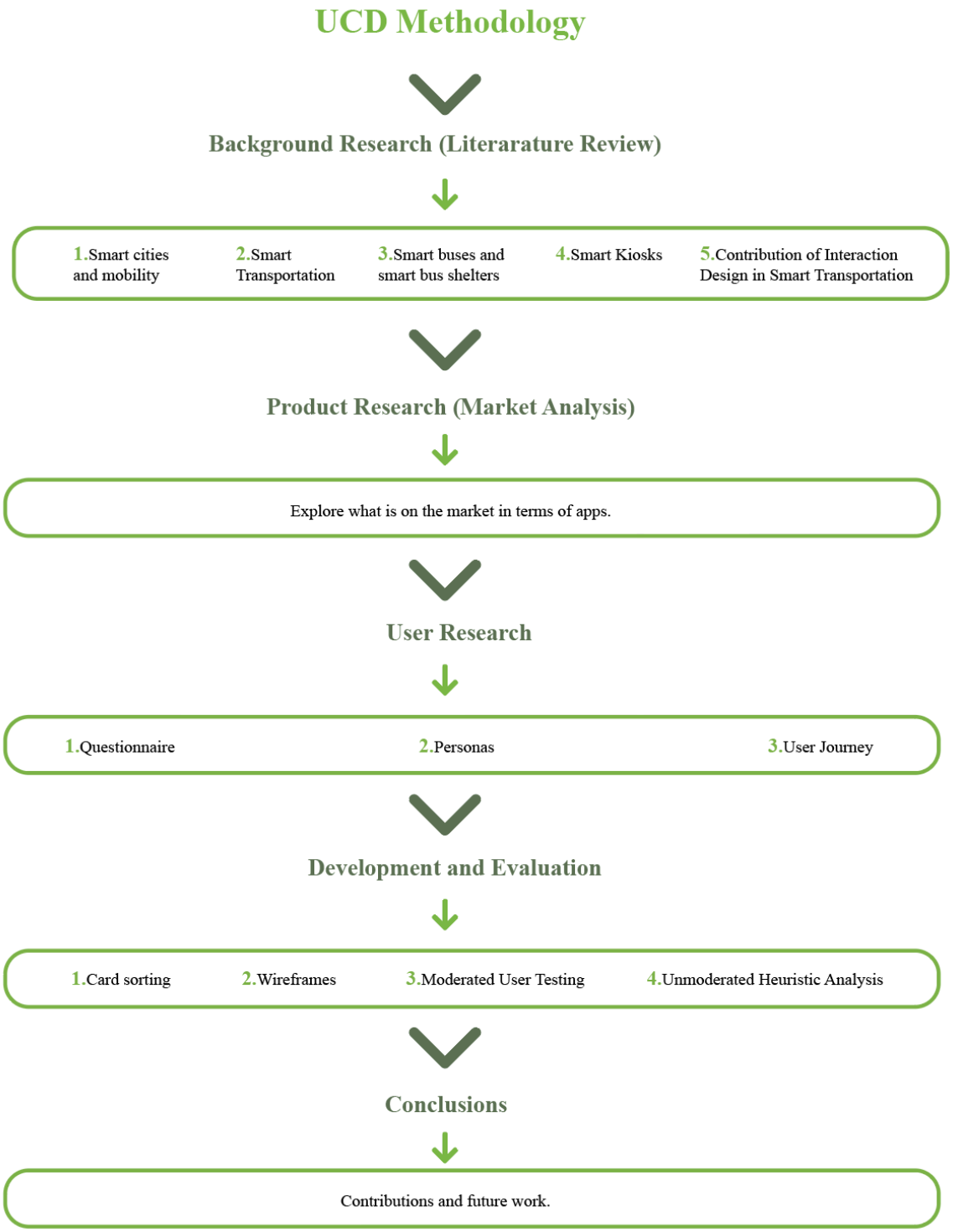
1.3. Objectives

The main goal of this research is to design and evaluate interfaces for smart bus and bus shelter that to encourage citizens to use public transport as a way to combat the sustainability problems of cities.

1.4. Critical factors for success

The main success factor for carrying out this dissertation was to find users to test the application throughout this process, from the first step, the survey to the tests related to the layout. These users, after completing the questionnaire, had to fit the profile of the personas created and, thus, were selected to respond to user tests. The moderate tests were executed during the Covid-19 pandemic, so there were some limitations, like doing the tests online.

1.5. Study diagram



1.6. Document organization

After introduction which consists of an introduction to the whole study, mentioning also, the motivation, objectives and the study diagram to this project, following document structures as follows:

Chapter 2: It focuses on the literature review to relate the main research topics. It addresses smart cities, exploring its sub-theme smart mobility. Within the theme of smart mobility, it is still possible to divide this into other sub-themes related to the perspective of an ecosystem directed to buses in a smart city. All of these themes are explored according to their basic concepts and possible applications and technologies, which can be associated with these themes and put into practice in the future.

Chapter 3: This chapter mentions the research methodology and methods that are used during the project development.

Chapter 4: It shows the project development and iterations. It starts by exploring the similar approaches already exist in the market regarding smart mobility and user research. In a second part it demonstrates the different phases from Ideation to the final tests of the interfaces designed for the smart bus and bus shelter.

Chapter 5: It concludes the study's results, limitations and contributions as well as mentions about the future work.

2. Literature Review

This second chapter is meant to expand/extend and deepen the knowledge regarding several topics such as smart cities and its mobility, smart transportation, smart buses and smart bus shelter, smart kiosks and contribution of interaction design in smart transportation making stating the most relevant articles and future prospects of such areas. Defining and explaining each of them and providing examples of what is already in use/implemented today and what is being thought for the future should the technology for its implementation ever arise or be developed in the future.

2.1. Smart cities and mobility

Smart city is a vision that have been growing for urban development that aggregates a lot of divisions of society with the help of the Internet of Things (IoT). The intention is to link and administrate a city's assets associated to health care, industry, mobility, policies, water and power like others as their information systems. This concept is born out of the concern of cities' grown, the different preferences of the new generations, the production and delivery system that is affected by the hyper-globalization and the epidemic innovation in the technological department. With these changes is necessary to update the cities to a smart living with smart surroundings that can promote a better life for its citizens by a smarter and united community (Mahmood, 2017). There is no unanimous definition of smart cities as the multiple scholars and practitioners view is different so there are multiple definitions (Kumar & Dahiya, 2017). However, in general, the concept of smart cities can be resumed by the efforts of the improvement of the quality of life for citizens by municipalities to make circulate information and improving the way that cities work. In a smart city have in count the data generating and for that is necessary to rely on systems, sensors and a platform that can manage and use the data recollected. This concept does its best to connect people to information and services like mass transport or social services. In a lot of centers there is no lower-cost broadband internet that creates digital divides in low income areas, so is necessary stations to bridge that divide with free Wi-Fi (Haynes, 2019).

A great example of a Smart City is the city of Austin, Texas which was a finalist in a US Department of Transportation (USDoT) competition called "The Smart City Challenge" due to its mayor's vision. Steve Adler, the Mayor, focus his vision for the city in the prioritizing citizens

access to work, school, and healthcare. The next step is bringing again the people who live in East Crescent that were pushed out of Austin because it became unaffordable. The biggest result of this will be "whether a senior citizen of the Eastern Crescent can get to her doctor without having to take a bus for two hours in each direction." (Lehr, 2018). It is possible to understand that here the great concern on this proposal was the mobility of the citizens. Summing up it can be said that the idea of a smart city is built on the interrelation between the humans, the technological infrastructure and the social capital as a way to improve the quality of life of its citizens (Eleutheriou et al., 2017)

2.2. Smart buses and smart bus shelters and smart Kiosks

The aim of the concept of Smart bus and Smart Bus Stops is to improve mobility in the cities, specifically in the buses. A lot of studies propose smart applications such as a smart application for smartphones that allows passengers to reserve seats only when they are in the bus stop, by a platform installed in the bus stop and they can also pay in this interactive kiosk. For the citizens that don't own this device they can also purchase and book the ticket only by the interactive kiosk. The veracity of the ticket has always to be confirmed by the bus driver. This application will be available in multiple languages for the convenience of all passengers (Kazi, Bagasrawala, Shaikh, & Sayyed, 2018) and by GSM when is offline (Rathod & Khot, 2016). The authors Kadam, Kaith and Patil proposes an application for Android devices that give the users information like where is the exact location of the bus, the arrival time of the bus to the bus station, the bus number, bus stops, bus schedules or the frequency and even how many passengers are in the bus. All of this will be possible by tracking the bus by GPS (Kadam, Patil, Kaith, Patil, & Sham, 2018). There is even an app that focuses on the wellbeing of children that is an application via web and mobile with the purpose of connecting the parents, the bus and the school. This will allow the school and the parents where are the kids in the bus and the time of arrival to the bus stops inclusive the school (Ghareeb, Ghamlous, Hamdan, Bazzi, & Abdul-Nabi, 2017).

Apart from being an application for smart bus shelters and smart bus there are more studies that take into account bus routes and calculate how long they take such as a small computer installed in the bus stops to give to the users the information about the exact location of the vehicles (Sungur, Babaoglu, & Sungur, 2015); to get a real time estimate to the bus arrival time to the bus stop can be achieved through a smart card data connected to a manual survey data and this smart

card would be used by the passengers (Zhou, Yao, Chan, Gong, & Lai, 2017); a stand in the bus station that gives the passengers the information about the bus as well as its location, this same information will appear in the bus so this is possible the authors bring together an amount of technologies such as GPS, LCD, GSM and Voice Announcement (Divekar, Shelke, & Patil, 2018) and there is even a study with the aim of enforce a smart bus tracker to shorten the waiting for the bus to passengers with the help of the RFID technology, so when a bus passes a bus stop an alert will be sent for people who registered for alerts (Nagalakshmi et al., 2016).

Bus delays are frequent and as such there are studies which allow them not to happen. The authors Sharad, Sivakumar and Narayanan had in mind a hardware solution that calculates the shortest track for the bus route all in real time. This will be possible by using an Artificial Neural Networks (Sharad, Sivakumar, & Narayanan, 2016). There is a study for a system that uses public transportation as transportability description platform for sensor nodes and bus stops used as sinks and with this system is possible to avoid the delays between the bus stops and the smart cities (Cruz, Couto, & Costa, 2019). The delays can also be resolved with an algorithm that recalculates the bus route in real time to escape the traffic and to the to its next stop on time (Harrath, Shaikh, & Siddiq, 2018). This investigation subsists in the creation of a system with a rout adjustment and a sub system, smart transfer, that can help the bus in the traffic but as well as the passenger's requests all in real time the simulation took place in SoHo area, in New York City, USA (Lee, Zhao, Chien, Wang, & Gao, 2016). The bus can also be controlled from within to inform higher officials of the departure of the bus, if there is a delay it is given a warning and the system used is GPS to control the bus (Karthikeyan & Jawahar, 2018).

These two studies present two different solutions to help inform the usual passengers of the buses. In the first study the smart bus subsists on two main technologies NFC and RFID with the purpose of sharing information on public transportation (Nassar & Vieira, 2017). The second one presents a wireless sensor network (WSNs) with the help of a voice module and an APR9600 audio playback system that can inform blind people where they are and where is the next bus stop. For this to happen the bus also has a GPS tracker (Holikatti & Kumar, 2018).

There are also a lot of studies developed to help, in general, make buses smarter, more efficient and more to the satisfaction of the general population who use buses daily as a mean of transportation. CitySys is a project for a smart bus stop. This smart bus shelter has integrated a lot of services such as the purchase of public transportation tickets, Wi-Fi, a space for advertisement,

locks for bicycles, purchase of food and drinks, monitors for the air quality and also the noise levels and heated seats. It's not all, it's assessable for kids and disabled people and have stereos for blind people. The smart kiosk is a computer that gives information and function to entertainment and education. This also connects people with the city and with this the city can prosper in touristic terms, since the maps and their history will be all connected in this platform. The smart kiosk will be controlled and managed by a remote administration, but the citizens can regulate the graphical interface as they please (OMS, n.d.).

To be able to control entries of the passengers was developed a smart card authentication on the bus to examine user's details with a RFID tag and if the user is authentic then she/he can pass and enter in the bus, if not is shown an error and won't be able to pass (Khedkar, Power, Gurdhalkar, & Karbhajan, 2016). The count of passengers can be done with the implementation of a system composed by Arduino Uno, Bluetooth HC-05, pressure pad, potentiometer and data collection software module (Sojol, Piya, Sadman, & Motahar, 2018).

Some of the biggest technology brands in the market have started betting on smart buses and smart buses stops. In 2015, during the UITP World Congress, Erikson proposed a bus stop that can provides comfort to their users. It includes 3G, LTE (Long Term Evolution) or Wi-Fi. The screens in the infrastructure display real time where the bus is and the touch-screens give access to information like interactive maps, news, information for tourists and advertising (Ericcson, 2015). In 2016, Nokia made a test for a smart bus stop, this occurred in Auckland, New Zealand. They surveyed the users, that were testing it, in order to understand how was their acceptance and the whole experience (Nokia, 2016). In 2019, BiATM a company located in London; UK developed a digital panel to insert in the bus stops shelters as well as a self-service ticketing kiosk (BiATM, 2019).

In terms of kiosks, mostly vendors want to install kiosks in community centers or for pedestrian traffic locations. These would give interactive portals in wayfinding, Wi-Fi, social media, advertising and search. In terms of design they are tall as a twentieth-century phone booth and have videos screens and a contemporary style (Lehr, 2018).

In the area of trading the Ticket kiosk systems should allow, according to Barnum (2011), the user to buy tickets for up to ten different events at once or in one purchase.

There are many scientific studies that use RFID-based technology to transform a kiosk into a smart kiosk, such as the following two: the first one proposes a "interactive kiosk based cart"

with the use of RFID technology to recognize product references that are accessible in a database this will facilitate customers to do their purchases (Sungur et al., 2015). The second one presents a kiosk with touch screen and RFID sensor with the ability of reading tags. As it is an informational kiosk also can communicate with a private branch exchange (PBX) that can change to allow the use of user profile in information center (CIC) or voice portal. The user information is restrained in a customer Relationship Management (CRM), so when the user utilizes the kiosk all the information will suit this user, according to the saved data (Frick, Kubach, & Schaper, 2003).

In a smart city it is important not only to take into account the inhabitants of this city but also the tourists who come to visit it and this study has that in mind when it proposes a smart interactive kiosk for tourism with the help of an automatic language recognition to realize what is the idiom spoken by the user, then it is used an Automatic speech recognition for excerpting of the keyword and last the system answers within a den of predefined responses (Jourani, Yakhlef, Echchelh, & Amessafi, 2017).

The aforementioned studies do not take into account usability which can make them unsatisfactory for users. Thus, the authors of the next research paper, named "Usability testing of a 3D touch screen kiosk system for way-finding", created a kiosk that achieved good usability testing results. It proposes a 3D touch screen kiosk and presents a series of usability tests in order to understand what usability problems users might have. In the end of these tests it has been proven that the tests made had a high rate of success for their interface (Tüzün, Telli, & Alir, 2016).

The OMS company has launched a smart kiosk that allows the user to access to information and applications for commerce, entertainment, communication and education, enabling the connection between citizens and the city. With this kiosk a new way of tourism was born, due to the availability of the historical information about the city and the amount of city maps ready to be consulted by everyone (CitySys, 2019). The brand Dibal created an interactive smart kiosk the Q Model directed to trade. It presents multiple functions such as supplying information on articles, identifying clients for consultation and print personalized coupons, exhibiting advertising, online purchases and finally soliciting a turn in different sections and check queue status (Dibal, 2019). Like Dibal, SmartMedia also design a smart kiosk for commerce (SmartMedia, 2019). Perless-AV developed a smart kiosk, for any appliance in a smart city, with IR touch overlays, cameras, routers, antennas (Peerless-AV, 2018).

2.3. Contribution of Interaction Design in Smart Transportation

2.3.1. Interaction Design concept

The human-computer interaction and user experience are connected to systems and software engineering. Often, the appreciation of human and user factor is not taken into account in the area of HCI (Human-Computer Interaction) and here enters the interaction design to help to create a great experience for the user (Barnum, 2011).

Interaction design is the interaction between the users and products with the goal of creating products that allow the user to reach their aim in the best way viable. Normally when people talk about interaction design tend to be talking about software products like websites or apps (Teo, 2020). It's a broad definition due to the field itself, but the interaction involves a lot of components like space, sound and motion. There is an imbricate between UX (User Experience) design and interaction design. UX is all about molding the whole experience of utilizing a product most of which implicates interaction between the product and the user. However, UX also has in mind two different steps: first who are the users and second why would they use the product (Teo, 2020).

Interaction design has five dimensions with the purpose of helping understand what does it involve. The first dimension is words (they should communicate information to users simply and meaningfully so as not to overload it), the second one is visual representations (it is about graphics with which users interact, completing words in the first dimension), the third is physical objects or space (it is based on the objects you use to interact with a product and the type of space the user is to connect to it), the fourth is time (refers to media that changes over time being that time and movement are essential for giving feedback to user according to their interactions) and the last one is behavior (this is how previous dimensions define a product´s interactions, including reactions, encompassing emotional responses and feedback from both users and the product) (Teo, 2020).

2.3.2. User Experience and Usability: a way of changing traditional transportation

The first requirement for an exemplary user experience is to meet the customer's exact needs without any problems or frustrations. Next comes the simplicity and elegance that produce products that are a joy to own and therefore a joy to use. True user experience goes far beyond giving customers what they say they want, or providing standard functionality. For a high-quality user experience in a company's offerings, there must be a seamless fusion of services across multiple disciplines, including engineering, marketing, industrial and graphic design, and interface design (Norman & Nielsen, 2018).

Usability has an international standard definition in ISO 9241 pt. 11 (ISO, 1998), which defined usability as the extent to which a product can be used by specific users to achieve specific goals with effectiveness, efficiency, satisfaction and other concepts in a specific use context (Sauro & Lewis, 2012).

Usability depends on certain organizational, cultural and monetary factors. What makes it usable is when the user has no doubts or frustrations about using an object, in another words, usability is when a product or service is usable, the user can do whatever they intend to do without any frustrations, hesitations or having questions or doubts (Rubin & Chisnell, 2008).

For the product or service to be usable it must also be useful and efficient, effective, accessible, learnable and satisfying (Rubin & Chisnell, 2008).

The usefulness is related to the degree to which the product or service enables the user to achieve their goals and gives an idea of evaluation to the product, since it implies the consumer's willingness to use it. If a system is easy to use and easy to learn, but if it does not fulfill a certain requirement of a particular user then it will not be used (Rubin & Chisnell, 2008).

Efficiency is usually a measure of time, but it can be said that it is how quickly a user can accomplish the task he or she intended. Often, this also implies that the product or service provides better user support than the current way they work (Barnum, 2011). It is related to how users think the product will behave and how easily users use it in the way they want it (Rubin & Chisnell, 2008).

The part of the product that can be learned is related to the ability of the user to operate the system at some defined level of competence after the so-called training period. It can also be

mentioned if users can relearn the system after some time without using it (Rubin & Chisnell, 2008).

Satisfaction of use is linked to the emotions, perceptions and opinions that the user may have of the product, this information is usually obtained through questionnaires. As a rule, a user will have a more rewarding experience with a product that meets user needs (Barnum, 2011b).

Usability goals are usually defined in measurable terms in the previously mentioned attributes. The numbers tell us whether the product "works" or not, however, there is no distinctive element to the term how usable it is (Rubin & Chisnell, 2008).

Accessibility can be said to be about having access to the products needed to reach a goal. But in this context, there is talk of accessibility in what makes products for people with disabilities usable (Rubin & Chisnell, 2008).

Making products more usable and accessible is part of user-centered design that encompasses various methods and techniques, transforming it into experience design (Rubin & Chisnell, 2008).

Peter Morville, co-writer of the book "Polar Bear", outlined some usability concepts, which he called "user experience honeycomb" (Figure 1). It was originally intended to explain the qualities of user experience that web designers should take into account, but it can also apply to product design (Barnum, 2011b).

Figure 1- "Honeycomb" de Peter Morville. Source: https://www.researchgate.net/figure/Morvilles-User-Experience-Honeycomb_fig2_322538093

Usability is a quality attribute of the UI (Figure 2) and user experience (UX) is an even broader concept that includes, then, the term usability (Norman & Nielsen, 2018). That is, Interaction Design is a part of UX.

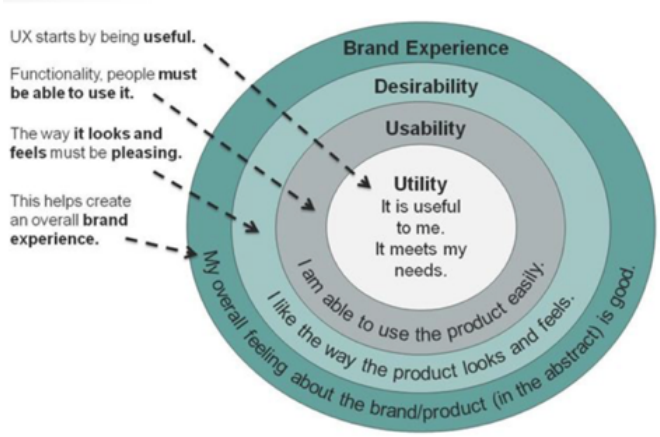


Figure 2- Representative diagram. Source: User Experience 2008, nnGroup Conference Amsterdam

Usability testing is a process that employs people as tested participants, representing a sample of the target audience, to assess the usability of a product or service. It can be said that it is a research tool based on the experimental methodology. There is a wide range of tests, however, each different approach has different goals, time, and required features (Rubin & Chisnell, 2008).

Many books on usability testing are intended to mention the activity that focuses on watching users work with the services or products performing tasks that are real and meaningful to them. Although much has changed over the years, even the possibility of not observing users when conducting unmoderated remote tests, the basic definition remains unchanged. Changes in technology, including access to users anywhere and anytime, coupled with changes in the purpose of testing means that the definition of usability testing needs to encompass many methods, practices, environments and conditions (Barnum, 2011).

It is possible to subdivide usability tests into two different categories according to what is already finalized and what is the purpose of the study, which are formative tests and summative tests. Formative tests are conducted while the product is under development to diagnose and correct problems based on small studies and repeated during development. Summative testing is

performed when the product or service is finished to understand if the product meets the requirements, requiring a larger number of participants for statistical validity (Barnum, 2011).

Respecting and using the concepts of usability and UX there is the "UX urban design" project which is a different point of view of building cities by shifting the planning and design of the 20th century space approach to the 21st century. UX Urban Design focuses on design and more specifically on UX design. Being that, the concept is to make the city for the user experience. Users are the foundation of the entire project, from the diagnostic phase through the management phase to the design project. This can all be accomplished through the Subjective Mapping tool that analyzes urban user experiences by adding users' layer for diagnosis and analysis. The data collected are feelings, imagination, perceptions and the outputs are stories, maps and interactive maps, all being information from the citizen's perspective. Quentin Lefevre gives us three methods to apply this vision. The first one suggests making a survey at a district scale asking the citizens what they like or dislike in the city and the results give a guideline. The second one points out giving voice to the kids, because they are considered "weaker users" so if the city is great for them, then is comfortable for every citizen. The third and last one is making interactive maps as analysis reports the content collected, such as videos or pictures, can be added to them (LE, 2018).

Still within the theme of smart cities there are several projects to improve the lives of its citizens, within the various areas that make up smart cities. Within the transport area there is Urbiotica and Bridj:

- Urbiotica (Figure 3) is a tech company that advanced the wireless monitoring systems to catch and release in real time what is going on in spaces of noise pollution and parking. The idea is to facilitate the parking, forwarding the users to the free spots, resulting in less congestion and pollution. In terms of the pollution the company developed a sensor that measures in real-time data and sends alerts when the noise exceeds the stated limit.
- Bridj is an app for intelligent public transport it handles big data to understand how and where the users want to go reacting with pop-up bus services. This app works with passenger inputs and real-time traffic data to optimize the bus routes to choose the quickest path, meaning the bus only stops at the points selected by the users on board.

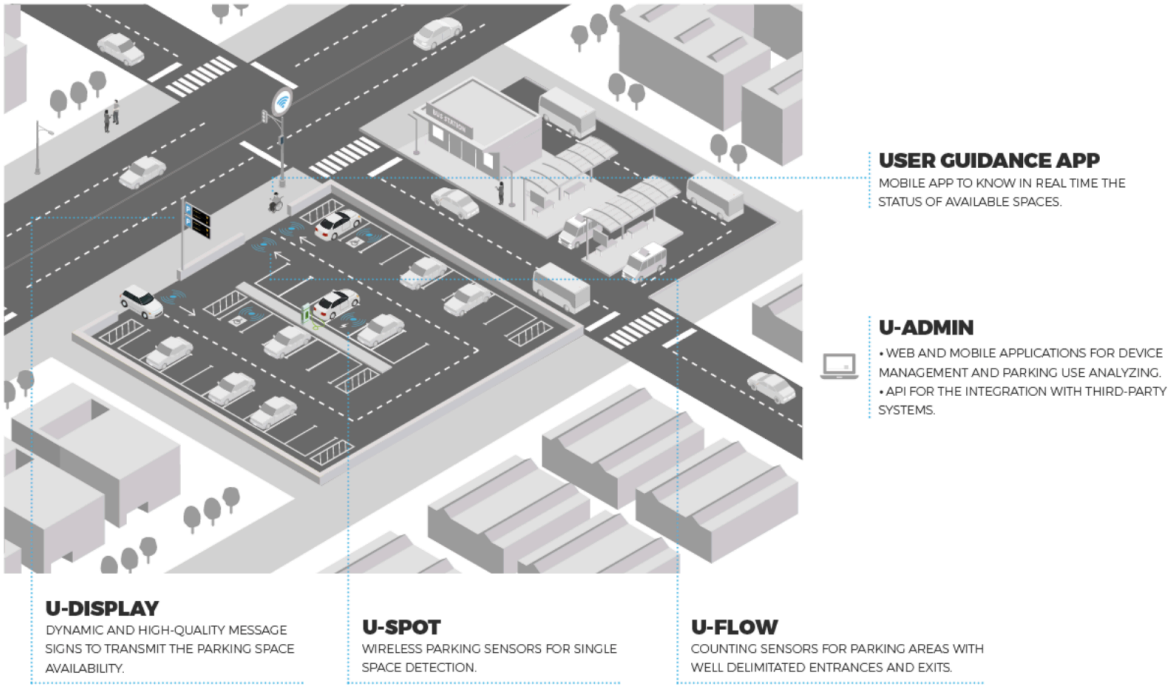


Figure 3 - Urbiotica parking solution. Source: https://www.urbiotica.com/en/smart-outdoor-parking-solutions/

In the culture area there is Mobile Age, user-friendly mobile applications using open government data, that has as main goal the involvement of seniors in digital public service, helping them to benefit from mobile technologies and open government data. In terms of waste systems there are two projects:

- Enevo (Figure 4) works with retail, restaurants, commercial properties and multifamily clients. Enevo measures the level of waste that there is in a container to manage operation in order to reduce the costs all because of the wireless sensors in the trash bins. The company also gain in overflowing trash prevention, increase in recycling, reduction in waste and less of missed collections.
- The circular Lab is an innovation center with the purpose of having the best practice in packaging and recycling. The tests occur in La Rioja, Logroño, to test packaging for the future, responsible consumption, improving techniques to recycle, waste management for smart cities.

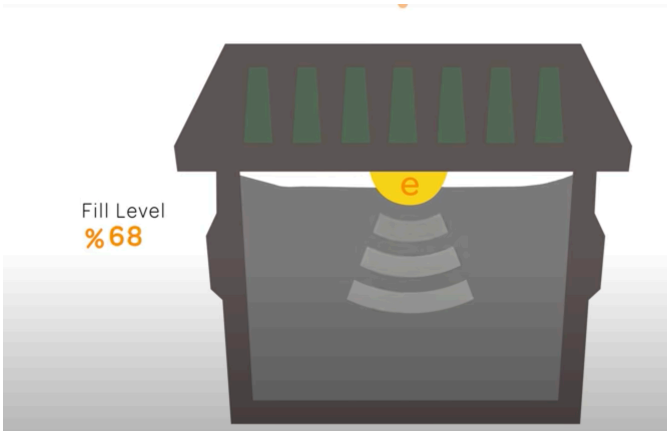


Figure 4 - Enevo solution. Source: https://enevo.com

In the department of energy Telensa is making apps to help cities save energy. This company is most known for its street light solution with more than million lights implemented around the world. With the remote control cities can control the amount energy used and measuring it in watts, reducing the maintenance costs (Blattmann & Echevarria, 2018).

However, it is not possible to know if these projects will be well accepted by the population when implemented, since there is no information that anyone has performed tests with users to test the usability of the product, according to the above-mentioned essential usability principles.

In West Hollywood, Los Angeles, there is a shuttle that visitors and citizens can take for free. The target of the PickUp is night time entertainment and young people that are public transportation adverse. This bus is equipped with photographer and a disco joker, a social media account and a card for discounts to popular nightlife businesses. They gave a good reason for people to use public transportation instead of driving their cars all by make it instagram-worthy destination. With this success the city is going to expand the shuttle to other streets (Mayerson, 2017).

According to Wolfgang Klein, lead UX designer at Star, visual HMIs have made successfully the computer personal, but not the computer a person. Also, the voice assistance is having some difficulties in machine learning and auto-driven interfaces, but the main adversity for HMI market will be telepresence technology like AR. They can annul the travel necessity, besides creating an immersive experience. This means that data and machine learning will be very important for comfort, personalization, connectivity and efficiency during the travel. Changing to driverless cars the automation area will need to make the passengers to trust in the vehicle in order to make drivers to take hands off the wheel (Lawrence, 2019).

2.4. Open issues

The main problem that is almost common to the majority of the studies is the fact that they don't take the users into account the user, the platforms and apps are not tested to know if they are user-friendly for their target. Only a few studies mentioned before such as the bus in West Hollywood, in L.A., in U.S.A (Mayerson, 2017).

The second problem found is that the studies in the areas of smart bus shelter, smart bus and smart kiosk would be more efficient as an ecosystem linked between them. With an ecosystem all the data gathering would function better to the bus companies and would transmit in real time information associated to the buses (such as schedules, delays and others) to the users. By becoming more user-friendly and giving a better service to the population is easier to attract the them to using more public transportation, such as buses.

3. Methodology

The main goal of this research is to design and evaluate interfaces for smart bus and bus shelter that to encourage citizens to use public transport as a way to combat the sustainability problems of cities. This entire process is focused on the User-centered Design (UCD) methodology. The UCD is an iterative process that is focused on the user and their needs and satisfaction. This entire process involves the user throughout the diverse stages like the search and the testing with this is possible to understand the whole user experience finding out the problems, what works properly and the reasons for both (Interaction Design Foundation, n.d.).

According to the methodology mentioned above this project was built in four stages:

1. Background research (Literature review);
2. Product research (Market Analysis);
3. User research (Questionnaire, Personas and User Journey);
4. Development and evaluation (Card sorting, Wireframes, Moderated User Testing, Unmoderated Heuristic Analysis).

3.1. Criteria for the literature review

The literature review of this thesis was built according to some books and scientific papers from the following data basis:

- Google Scholars;
- IEEE;
- B-on;
- Research gate.

To do this research was used some important keywords like:

- Smart transportation;
- Smart buses;
- Smart bus shelter;
- Smart kiosk;
- Smart cities + smart mobility;
- Interaction Design + smart cities;

- UX + smart transportation.

The results of this research can be summarized in the following topics:

- Interaction Design;
- Smart cities and its technology;
- Smart buses and smart kiosks and the way they operate in a smart city;
- The problems associated with public transportation and ways of resolve them.

3.2. Methods

Multiple methods from UCD were used to achieve the objective of this study. This section will show the methods per stage and give information about these methods.

3.2.1. Stage 1: Background research

3.2.1.1. Literature review

The literature review is fundamental step to start a study it serves as market analysis of the studies that gave already been done, proposing aspects of these that can be review and improved (Creswell, 2014). This step was very important to increase knowledge in the following areas: smart cities and mobility, smart transportation, smart buses and smart bus shelters, smart kiosk and contribution of Interaction Design in smart transportation.

3.2.2. Stage 2: Product research

3.2.2.1. Market Analysis

The market analysis is a way to identify and understand the needs between the market and the purpose of an institution, even more important if it's applied to studying a new or previous studies (Groff, 1981). This step was very important to understand what were the apps that have already done some similar to this project and what was missing on them.

3.2.3. Stage 3: User research

3.2.3.1. Questionnaire

The questionnaire method is a written method that is used to gather information from study subjects (World Health Organization, 2008). For this questionnaire it was expected to have a sample of about 200 answers. The variables to be tested are existing problematics (independent variable) and satisfaction (dependent variable). With this method we intend to understand the sociodemographic conditions that influence or not to use public transport, namely buses, what are the problems that exist in buses and still use any existing application that facilitates the use of this type of public transport. With the results of this investigation was possible to know the problems that exist in buses and try to design the app according to those problems and try to resolve them.

3.2.3.2. Personas

Personas are characters created based on real information with the purpose of exemplifying different users that would use a solution, a product, a site, a brand or a service in a near way (R. F. Dam & Siang, 2021). The results of the questionnaire helped to define the target for this work and with that information was possible to define three personas and one anti-persona to represent the target in question.

3.2.3.3. User Journey

The user journey map shows the interaction between the persona created with the product, service or brand through time (Babich, 2019). This method was essential to understand the relationship between the system in development over the time and if it was going to be accepted.

3.2.4. Stage 4: Development and evaluation

3.2.4.1. Card sorting

This method shows how people think content should be organized and named, and is often used to generate a hierarchy of information. This refers to the organization of the structure and content of a product, to the labeling and categorization of information, and also to the design of

navigation and research systems. Good architecture helps users to find information or items, performing their tasks with ease. Since information architecture focuses on three concepts: “organizing content or objects”, “describing them clearly” and “providing ways for people to reach them (Spencer, 2010). The card sorting, has the purpose of validate or not, the hierarchy of information presented in the navigation plan.

3.2.4.2. Wireframes and Wireflows

Wireframes are a common deliverable to help visualize the user flow, the information hierarchy, the interactions between the user and the platform and the pages layout. The fidelity of the wireframes can vary from sketches (low fidelity) to very approximated representations of the final design (high fidelity) (Gordon, 2021). The wireframes in this process were very important to organize all the information that was essential to be on the platforms and to visualize how would be the flow between wireframes.

3.2.4.3. Moderated User Testing

Moderated tests give a better chance to the researcher to understand what are the problems with the platform that is being tested since it allows the moderator to visualize the participant in real time, give them instructions and ask them follow-up questions specific to that participant’s test (Whitenton, 2021). The moderated test was built in order to evaluate and assess the usability of the wireframes of the platforms.

3.2.4.4. Unmoderated Heuristic Analysis

In unmoderated tests the software gives the instructions to each participant not needing a researcher to moderate the test (Whitenton, 2021). The heuristic evaluation is a test where experts of the area report the interfaces errors according to the Jakob Nielsen’s 10 heuristic thumb rules, revealing insights where the usability product can be improved (Interaction Design Foundation, n.d.). The unmoderated heuristic analysis had the purpose of evaluate and assess the usability of the layouts of the platforms throughout the vision of the experts in the area.

4. Project Development

4.1. Market Analysis

In this research the market analysis has the purpose to analyze the applications that are in the market and what features do they have. It also contributes to understand what innovations can be done to improve what already is in the market.

4.1.1. Method

Market Analysis was done by researching on the internet and by asking to the participants of the questionnaire presented in section 4.2.

4.1.2. Procedure

The research was divided into two distinct platform. The first platform was Google and the second one was App store. The keywords searched on Google were: Transportation + Apps, Maps + Apps and Lisbon + Transportation + Apps. The keywords used to search on the App store were similar to the Google search: Public + Transportation + Apps, Transportation + Apps, Maps + Apps and Maps + Lisbon + Apps.

4.1.3. Results and Conclusion

There are a lot of apps that serve as a guide to people or for a public transportation. These kinds of applications can be divided into Nacional or global, public transportation and GPS applications. In public transportation it is possible to see applications such as Carris, Citymapper, Moovit, Uber, Bolt, FreeNow and LisboaViagem.

In terms of GPS applications there are some well-known like Google Maps, Waze and Maps. All of these apps can be divided into Nacional (Portuguese) and foreign, so the Portuguese ones are Bora, Carris and LisboaViagem, all of the others are foreign.

Specific parameters were set to analyze the applications. The parameters were divided as: contents, design characteristics and interaction.[1]

[1] Tables presented in Appendix A.

The content parameter is divided in the following topics: Register, Log in, Maps, Payment, Location (GPS), Notifications, Voice Command, Routes, Favorites, Personable Icons, Developers Contact, Account, Grade the App and Terms of the App. According to the content most of the apps have a register, log in, payment, maps, location (GPS), notifications, routes, favorites, account, search and terms of the app. It was not common to find among the apps that use voice command, personable icons, developers contact, grade the app and share the app. The features that are more present in these applications are the Search, the Maps and the Location, with only one application (Suprimidos.pt) that doesn't have it. The content that is the least presented in these applications is undoubtedly the developers contact that only Suprimidos.pt has, the feature more present in the apps is the Voice command which can be found in Google Maps and Waze. Of all the features that were evaluated, the most diversified were maps and payment methods. If we go deeper into the payment functionality, we can understand that of the few applications that have this functionality, only one of the four studied works with Apple Pay while the rest work through the registration of Visa or Mastercard credit cards. Of the ten applications, five use Google Maps as the Default map, two use Apple's Maps and two others have their own map (Waze and Citymapper).

The Design Characteristics parameter concerned with the following topics to analyze the graphics of the interface: Primary Color, Secondary Color, Typography Titles, Typography text and Icons. In terms of colors, the most primarily used color was the blue found in five apps and the second most used colors were the blue and green used by six apps. In terms of colors the least primarily used colors were the red, Green and Grey each used by only one app. Secondary color that was used the least were grey and orange only one app used each of them. The typography, both tittles and text, that is possible to find in the referred apps are sans-serif. It should also be mentioned that the icons present in the Uber application are more realistic than those in other applications.

The Interaction parameter is divided in the following topics: Tap, Drag, Pinch, Flick, Swipe, Double Tap, Pinch and Hold Shake Rotate. This were the topics chosen according to Apple's Human Interface Guidelines (Apple, 2021). Results show that the majority of the applications uses the following gestures: tap, flick, swipe, double tap and pinch. The Tap gesture is without any doubt the most exploited gesture in applications. The least used gestures are rotate, used by three apps, and touch and hold, only used by one application. However, none of them use the drag gesture.

The results of the market research help to build the wireframes. However, in order to build a better content for the project the studies focus on the study of users and their daily habits and their application to public transport.

4.2. User research

User research is crucial to understand the needs and pain points of the users. To make a design to have into account these parameters, designers have to use different methods to find important information and the principal problem and opportunities to use in the process (Interaction Design Foundation, n.d.).

In this case the key is to understand who are the users of public transportation, what are the problems are associated with these means of transportation (such as buses), if they already use any apps to help them in a daily base and another central questions. This kind of information helps to define the target, the main problems in public transportation and where can be improved.

4.2.1. Method

A questionnaire was used to gather data[2]. With the information from the questionnaire the target was found and from the target were build personas (and one antipersona), the scenarios and the user journey.

The questionnaire was created in Google forms which was essential to reach and collect a good amount of data.

4.2.2. Participants

324 participants (218 female and 106 male) responded the questionnaire.

4.2.3. Procedure

This study consists of two phases. First, an exploratory research design was carried out to collect secondary data and analyze it. And, in the second part, was conducted a conclusive research

[2] Presented in the appendix B (is in Portuguese since it is meant for the Portuguese population).

design using descriptive research to test the components and the research questions raised in the first part of this investigation.

Sampling was carried out using a non-random technique, since there is no knowledge of the probability of selecting each element of the sampling, because doesn't have a survey base to carry out this questionnaire. Bearing in mind that the questionnaire was shared by social networks (e.g., Facebook and Instagram) and, furthermore, the respondents were asked to share the link later, therefore the snowball sampling technique was used. This technique allows for a broader collection of responses at the beginning it takes time to collect, but in the end more responses are obtained, since there is a sharing of the questionnaire link by the respondents. The questionnaire was built by using google forms platform and the link was shared on Facebook and Instagram. It was created to only take about seven minutes of the time of each inquired and it was only complete to send the answers after every user answered to every required question.

The main goal of this research is to design and evaluate interfaces for smart bus and bus shelter that to encourage citizens to use public transport as a way to combat the sustainability problems of cities. To reach this goal was crated a questionnaire to understand the main problematics associated with public transportation and the reasons that lead people to not use them and the use of applications that simplify the usage of public transportation.

The questionnaire is divided into three parts, the first one refers to sociodemographic data, the second to public transport and the last part to applications associated with public transportation.

The first part of the questionnaire, referring to the sociodemographic data of the respondents, serves to characterize the population using mostly public transportation. The second part concerned aims to assess what are the real problems that exist in public transportation, namely in buses, and what are the routes that the population uses the most and how many times a week they use buses as a means of transport. The third part focuses on the existing applications that make the use of public transport simpler, what these are and what are their best features.

This questionnaire presents multiple questions, these are screening questions, warm- ups, transitions and development[3].

4.2.4. Results and discussion

In this next section it is possible to see the results of the questionnaire divided into three categories: Sociodemographic data, Public Transportation and Applications.

4.2.4.1. Sociodemographic data

One quarter (25%) of the survey participants age is between 20 and 30 years old and the group age with less answers is the people with less than 20 years old which corresponds to 3% of the total.

In terms of the female gender the majority of the answers were given by women with ages between 20 and 30 years old which corresponds to 25% of the total of the female gender answers. With respect to male gender, the most of the contributes were given by men with ages between 30 and 40 years old which corresponds to 34% of the total of male gender.

As to the geographic origin of the participants, as we can observe in the following graphic, most of them (61%) lives in Lisbon's district, followed by Castelo Branco with 13% and Setúbal with 10%. The rest of the respondent's origin is scattered by other locations with very low values[4].

Regarding the education level, the results showed that people with higher level of studies are in the group age of 20 to 30 years old.

As to the level of education by gender it's possible to conclude that female have higher education level than even in the PhD levels (Figure 5 and Figure 6).

[3] The differentiation between the questions is presented in the appendix C.
[4] Graphics presented in appendix D.

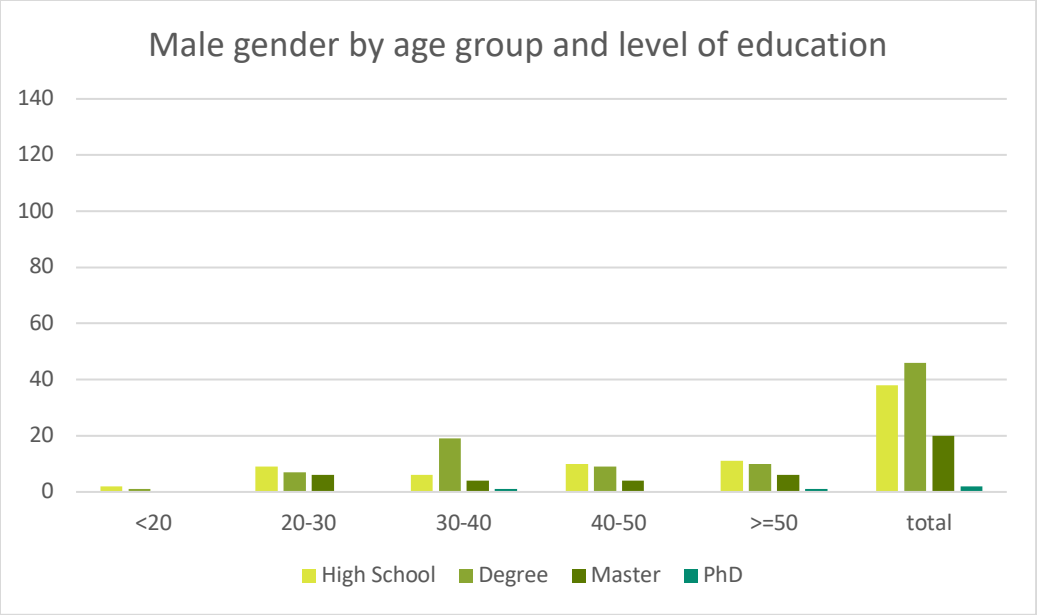


Figure 5 -Male gender by age group and level of education

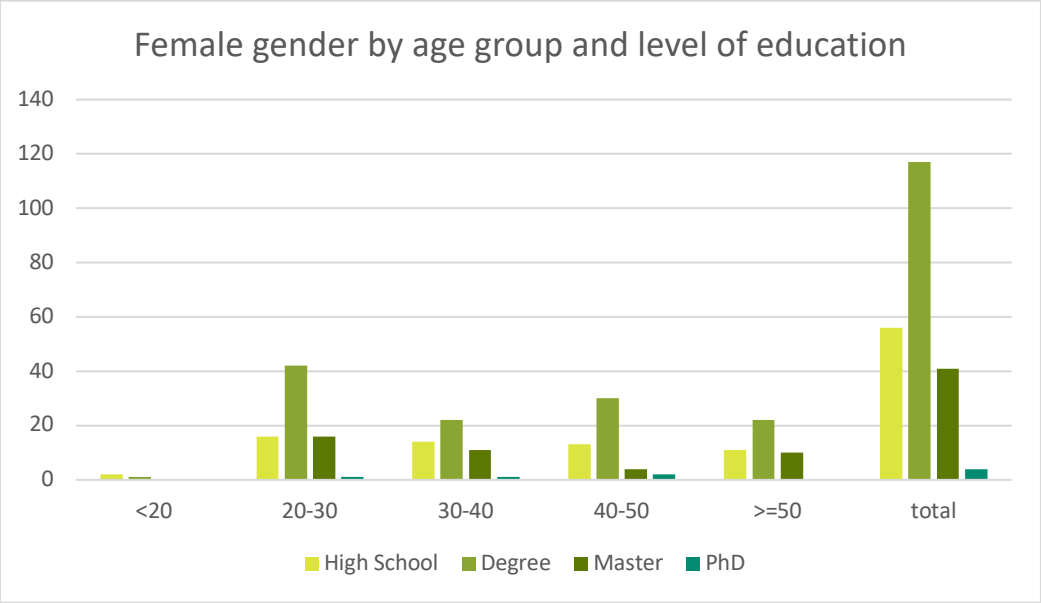


Figure 6- Female gender by age group and level of education

In conclusion, most of the participants were women with ages between 20 and 30 years old. In total, most of the respondents lived in Lisbon. Also, the same group age has higher level of education and in terms of gender are also women.

4.2.4.2. Public Transportation

As to the use of private car according to the answers given it's used by the majority for work/ School, leisure and at the weekends what makes 35% of the total (Figure 7). Only 1% of the participants use it only for work/ school and at the weekends, that is most of the inquiries use the car for almost everything. And as can be seen in the Figure 8 that conclusion is valid for every age group.

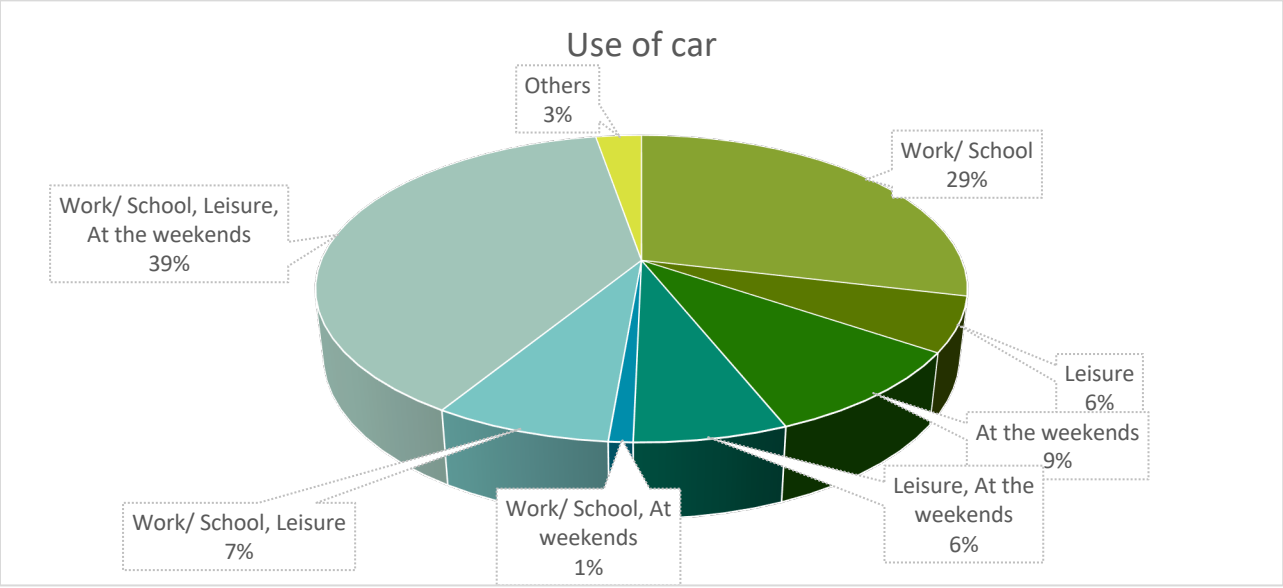


Figure 7 - Use of car

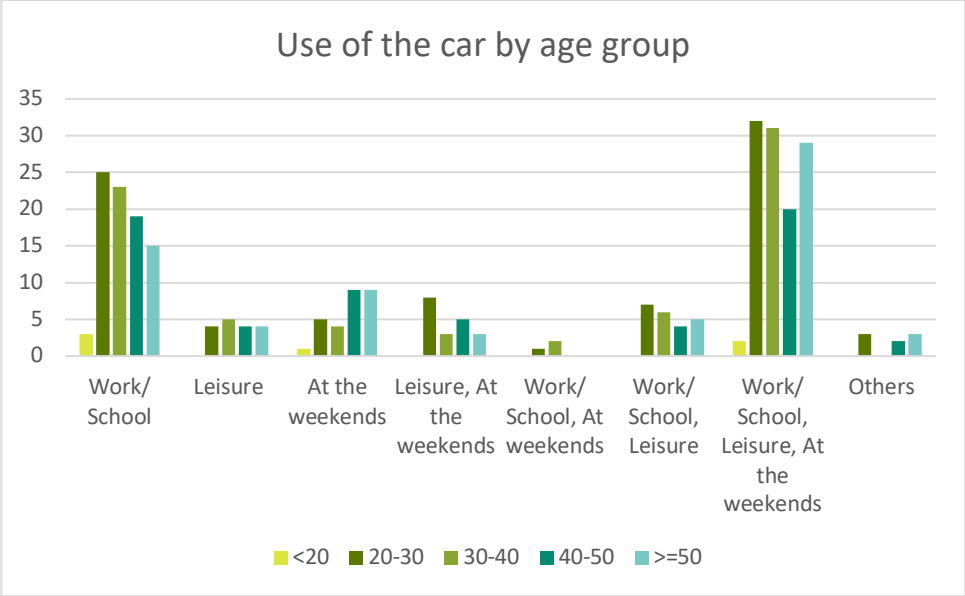


Figure 8 - Use of the car by age group

Figure 7, presents the majority of the inquired ones use the car in a daily basis 55% of the total (Figure 9).

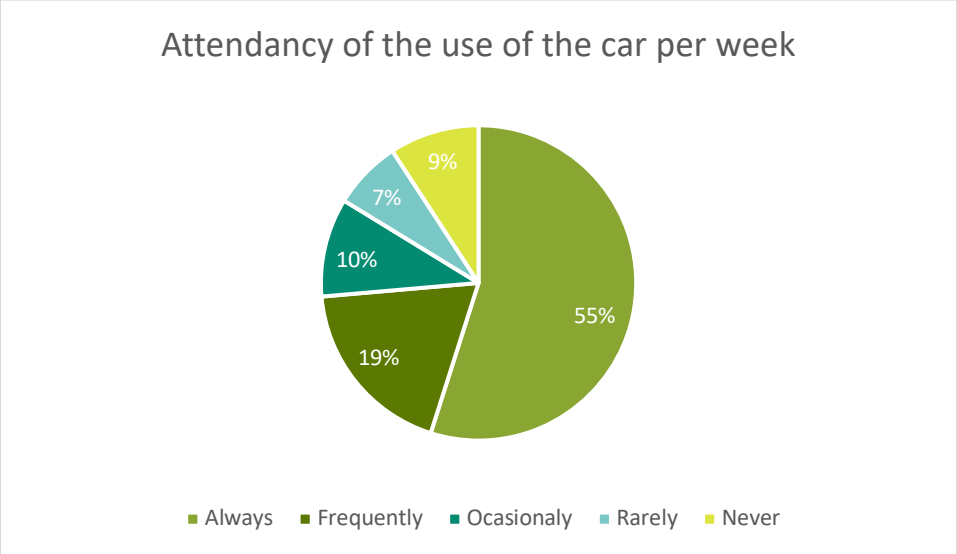


Figure 9 - Attendancy of the use of the car per week

The sample (Figure 10) reveled that 44% use public transportation for their daily routes and according to Figure 11 the age group that most uses these means of transportation are the people between 30 and 40 years old. However, this age group is not the one with higher education showing that people with higher education do not prefer the usage of public transportation. It can

be maybe associated with public transportation being cheaper or even maybe with the fact that some transportations are faster like metro due to the fact that it doesn't hit traffic.

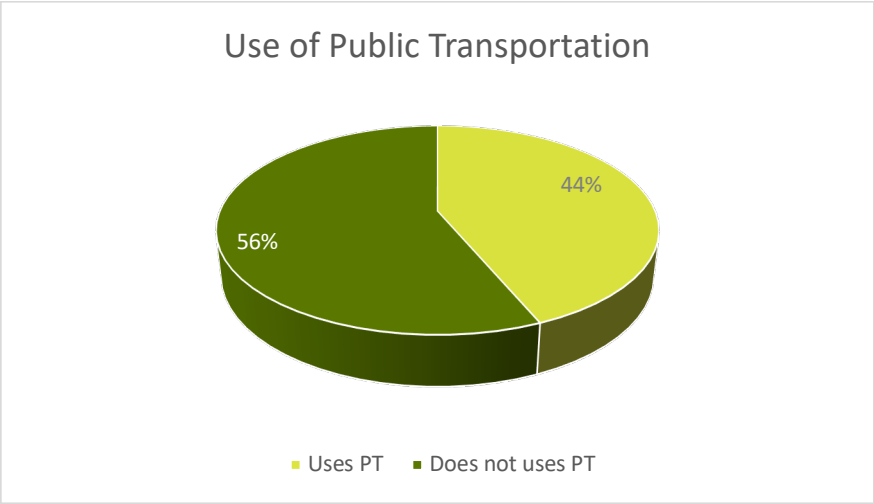


Figure 10 - Use of public transportation

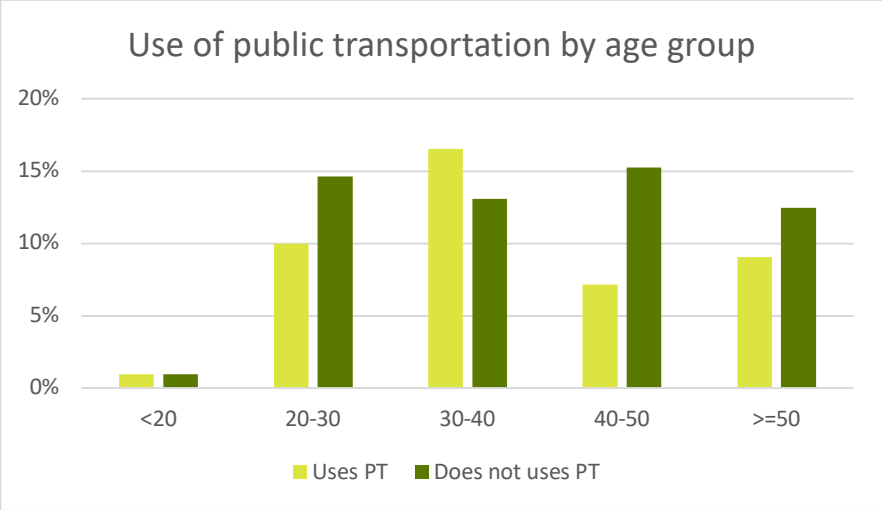


Figure 11 - Use of public transportation by age group

People who prefer public transport (Figure 12) use mostly for house-work line which corresponds to 39% of the total. However, not far behind with 38% people use for house-work-leisure. As it's possible to observe in the Figure 13 the majority of the answers given demonstrate that most users utilize or always or frequently the public transportation.

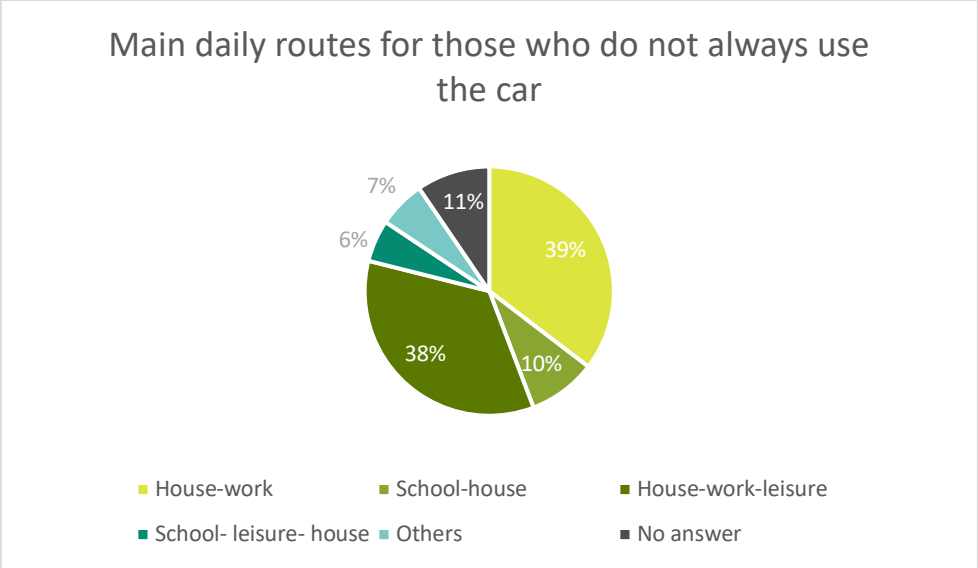


Figure 12 - Main daily routes for those who do not always use the car

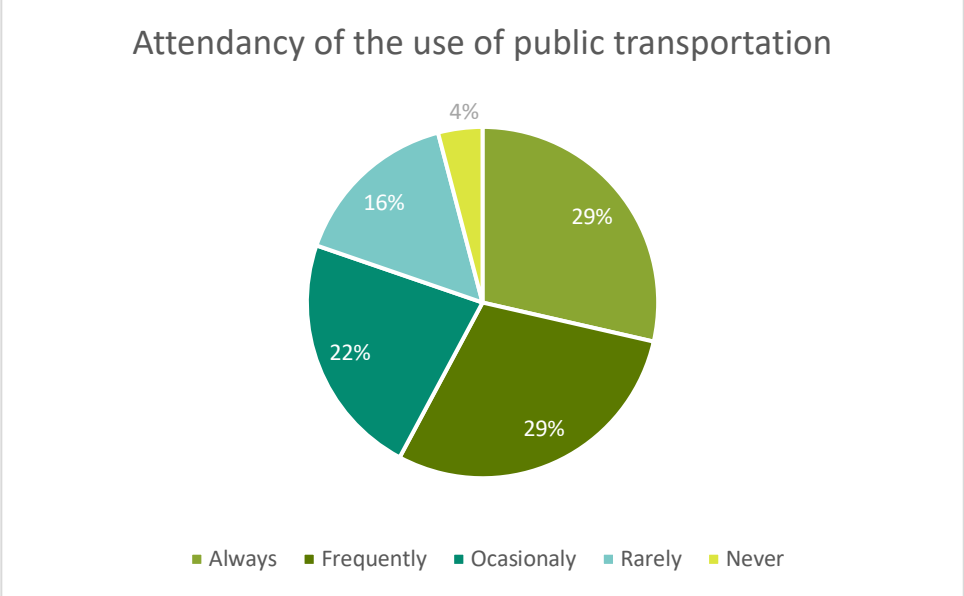


Figure 13 - Attendancy of the use of public transportation

The most used public means of transportation (Figure 14) are the metro and the bus (combined or not), and this happens due to the fact that 61% of the sample lives in Lisbon, where there is metro.

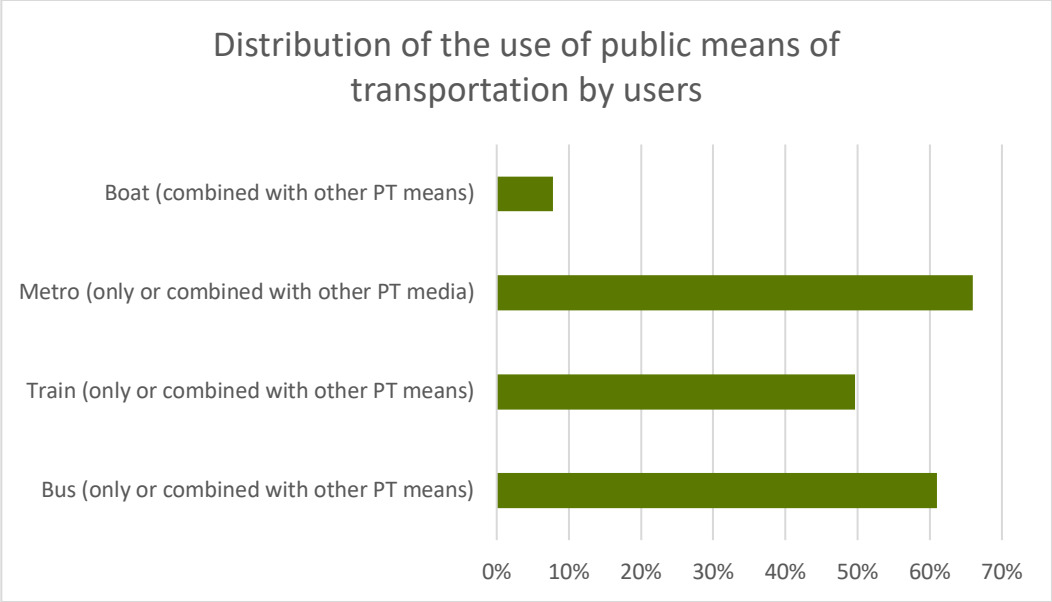


Figure 14 - Distribution of the use of PT by users

The most frequent problem that the participants mentioned the frequent delays that correspond to 33% and buses with excessive capacity with 26% of the total. Additional to these problems, some participants were also mentioned: “being less safe and comfortable”, “being very limited in terms of schedules and catch traffic like cars” and “Transport does not effectively cover the entire city, nor does it have the desired frequency for a network that allows you to leave your car at home”. Here, it is possible to conclude that perhaps if the transport network were improved, young adults between 20 and 30 years old would opt for the daily use of public transport, taking into account all the problems mentioned by the participants.

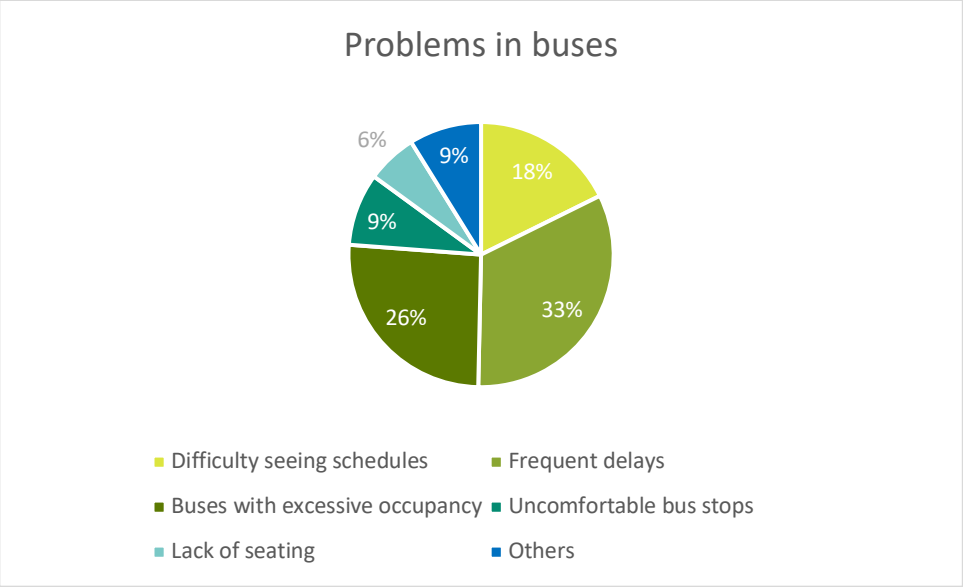


Figure 15 - Problems in buses

In this questionnaire, it was important to understand the different facts that cause people to use the car instead of public transportation, Figure 15 presents the main ones. Even with a lower percentage (6% in total), is crucial to see that one of the problems, is the lack of seats on the bus, Figure 16 demonstrates that most of the participants said that they occasionally or rarely can get a seat on the bus.

Figure 17 shows that in 29% of the cases the lack of seating causes the participants not to use the bus.

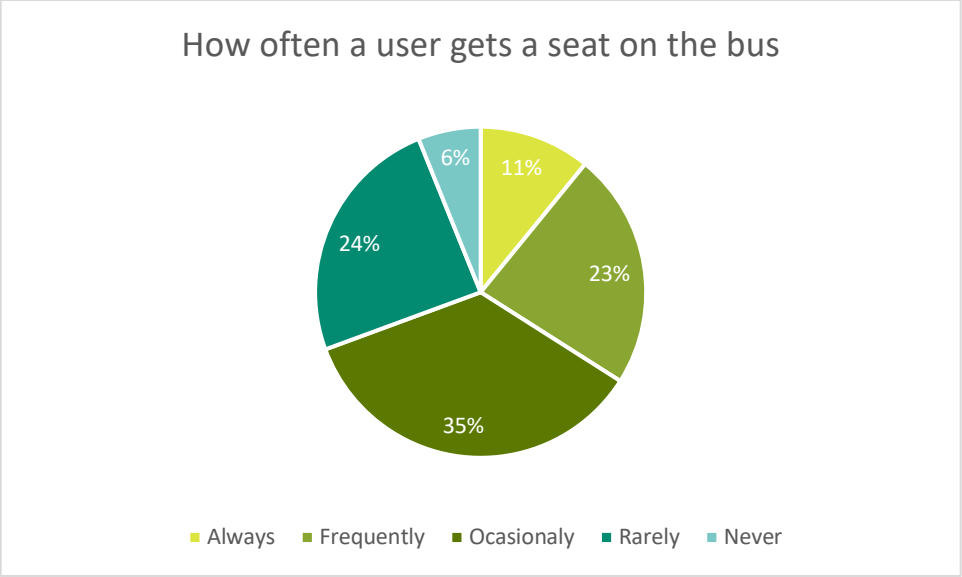


Figure 16 - How often a user gets a seat on the bus

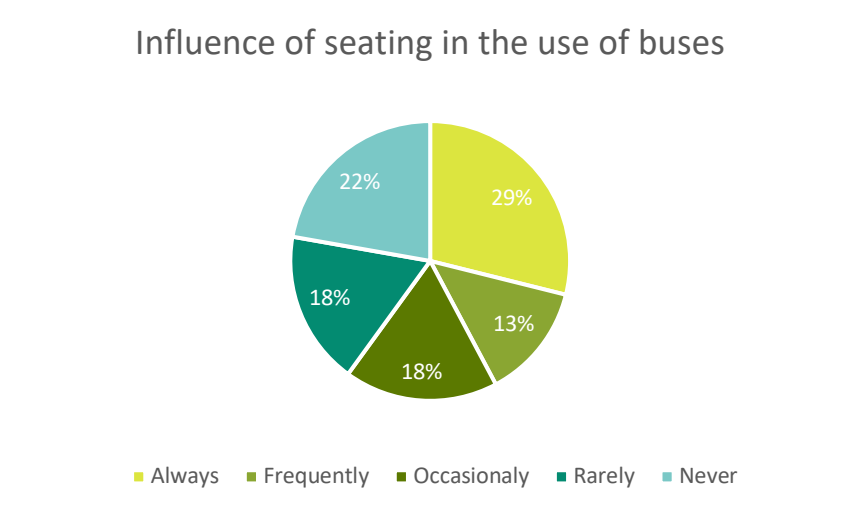


Figure 17 - Influence of seating in the use of buses

A lot of the participants feel that there should be more frequency of buses in some schedules (Figure 18). The morning (8h-10h) is leading the demand with 39% of the total but only with less 3% there is the afternoon schedule with 36% of the total. Some people even suggested other schedules like "6h-9h and 17-20h", "out of the rush hours", "At every hour, because not everyone has the same work schedule" and "During the week, from 7 am to 1 pm, after 4 pm to midnight, during the week, and on weekends the underground should be open 24 hours, as is in other European capitals, and buses with extended hours and safe routes".

With these results it's possible to understand that it is necessaire to add more frequency in the morning and afternoon schedules. However, still some people would like to see buses working 24/7 in similar schedule.

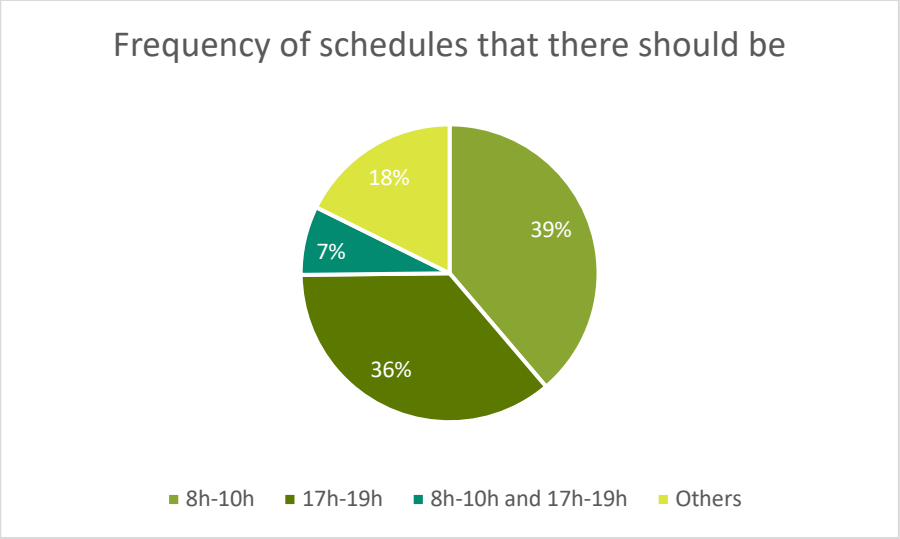


Figure 18 - Frequency of buses schedules that there should be

The graphic below (Figure 19) represents what the participants think of the bus's punctuality. Most of the participants (35% of total) believe that the bus is occasionally on time. Figure 20 shows that the participants are in the opinion that the lack of punctuality of the buses is a reason for not use them. According to the results presented, it is clear that it is necessary to have buses that respect the stipulated schedules so that they can meet the citizen's needs and get them to use buses as form of transport.

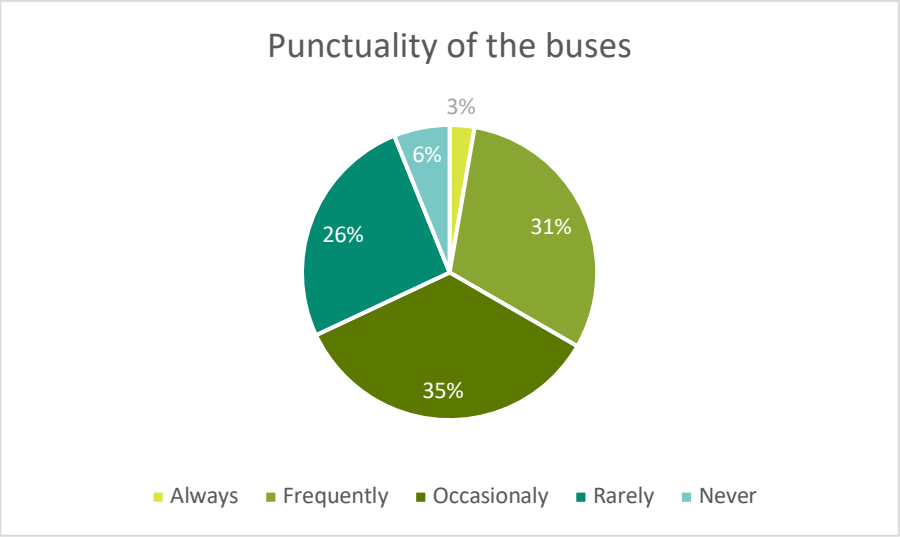


Figure 19 - Punctuality of buses

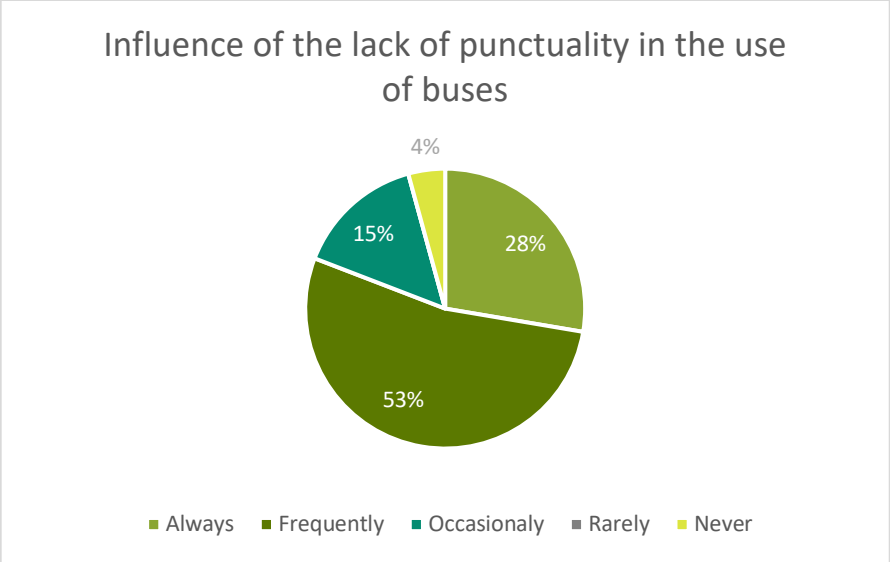


Figure 20 - Influence of the lack of punctuality in the use of buses

4.2.4.3. Applications

Through the following graphic (Figure 21) it is perceptible that most of the participants that travel by bus don't use the text message, that is on the bus shelters, as a way to know how long will take the bus to get to that bus stop. The participants that actually use this service (always, frequently, occasionally or rarely) are not really satisfied with this service as Figure 22 shows from 1 (not satisfied) to 9 (completely satisfied) the satisfaction of the participants. Most of them feel neutral about this service instead of feeling completely satisfied, which shows an area that has to be into attention. The fact that this type of help (sending a message to know where the bus is) is static and not dynamic leaving no space for more interaction between the user and the service, may be a reason for the lack of user satisfaction.

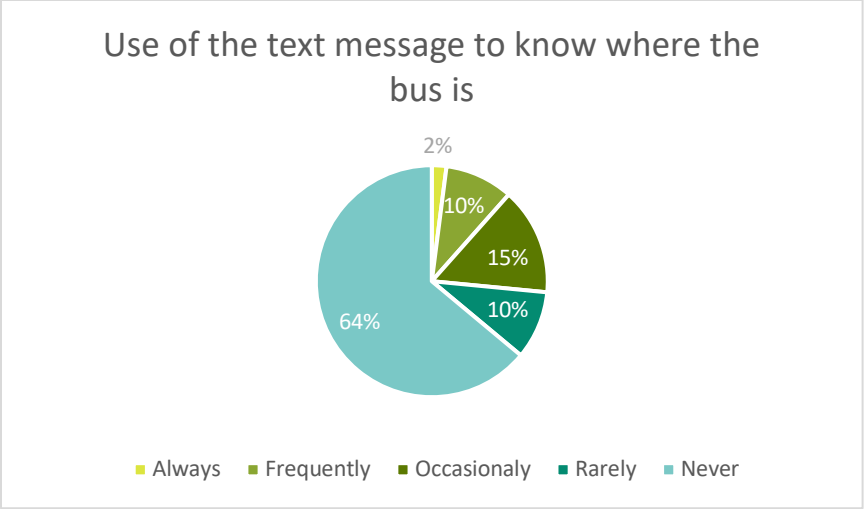


Figure 21 - Use of the text message to know where the bus is

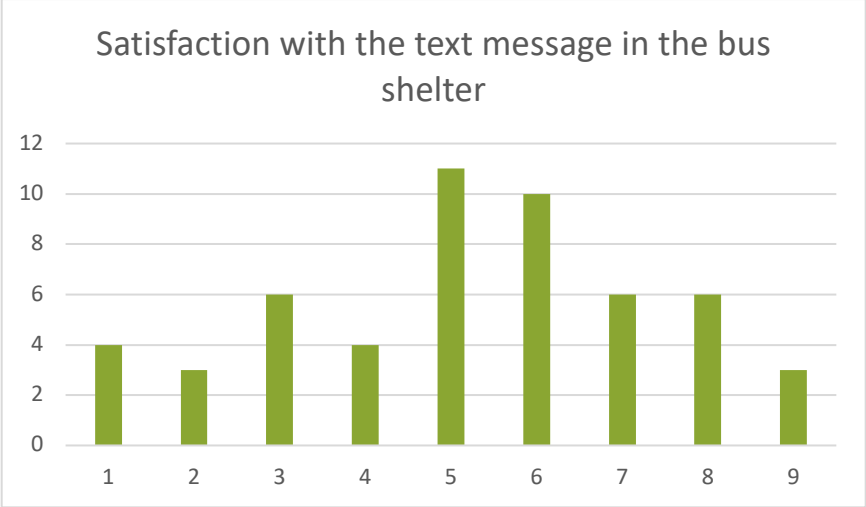


Figure 22 - Satisfaction with the text message in the bus shelter

The Figures 23 and 24 are related to the knowledge and the use of apps that help users to use public transportation. The following graphic (Figure 23) shows that most participants don't know any apps, and that the most known app is Google maps. Some inquiries said that they don't know any apps because they "don't need" or "The waiting times indicated in the app differ from those practiced". In Figure 23, the most used applications are Google maps with the leading percentage (56%) followed by Moovit with 14% of the total. There are some users that rely on other apps like "Move-me", "MyRL", "Face4" and "Fertagus" that are mentioned in the "others".

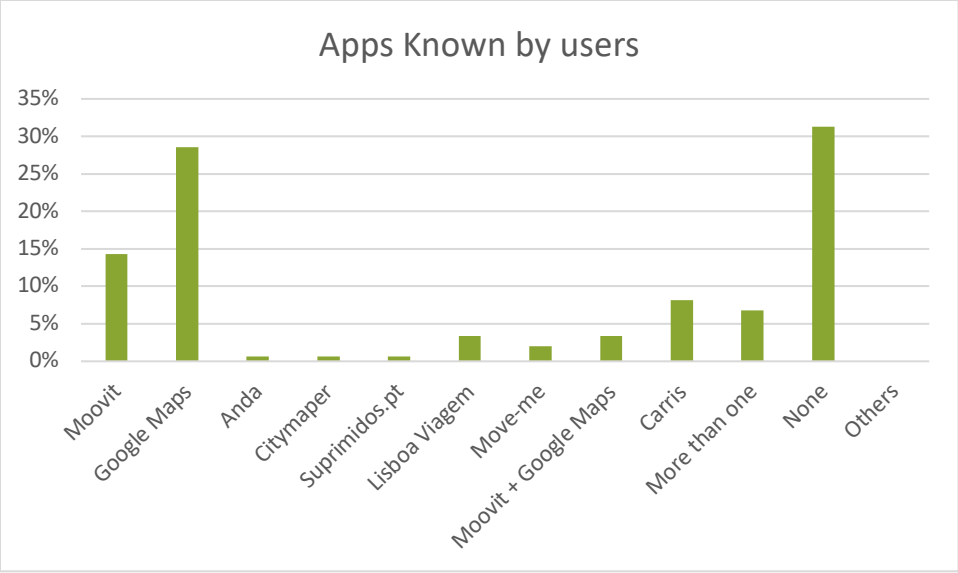


Figure 23 - Apps known by users

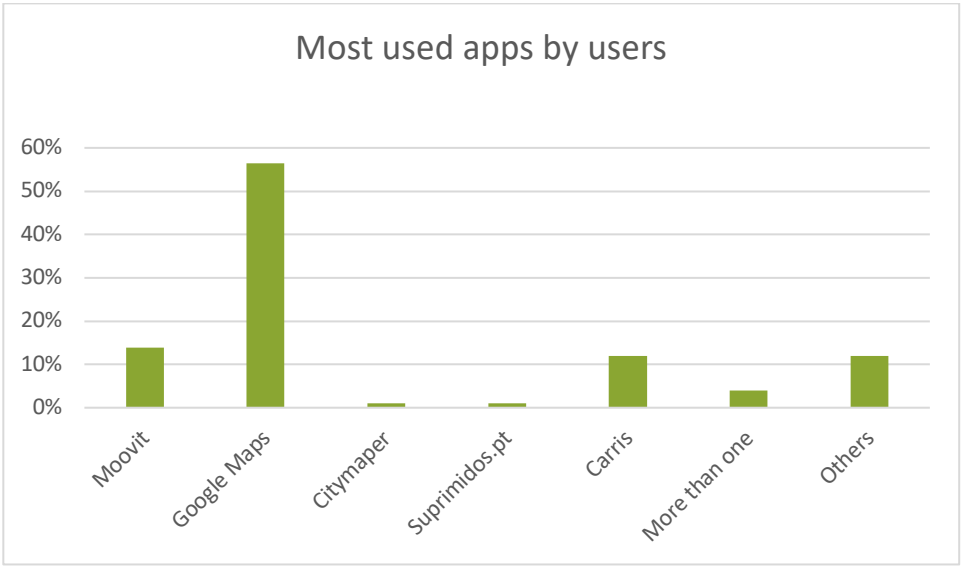


Figure 24 - Most used apps

Most of the users frequently utilize the apps (Figure 25) for diverse purposes like see the schedule or to see bus routes, but the majority uses to see which is the route of the fastest means of transportation (Figure 26).

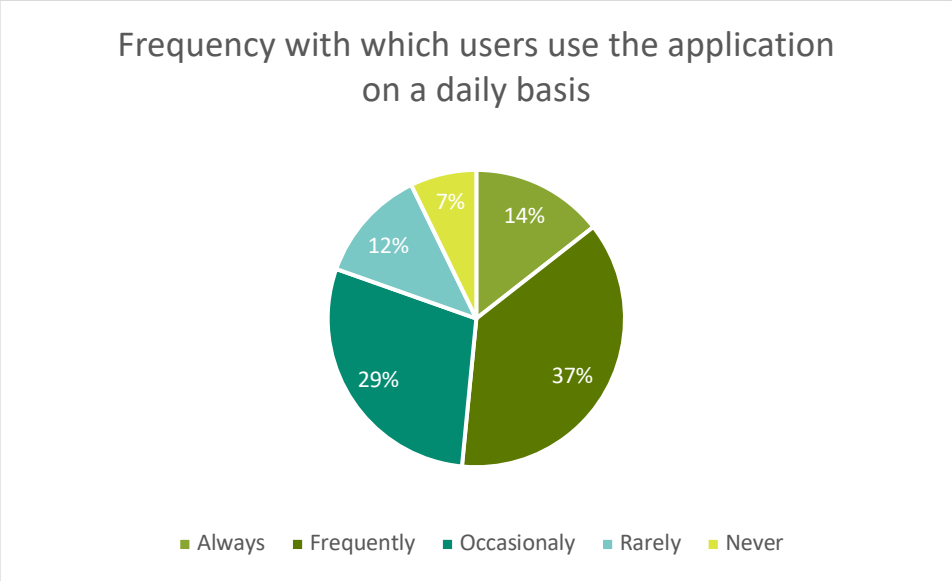


Figure 25 - Frequency with which users use the application on a daily basis

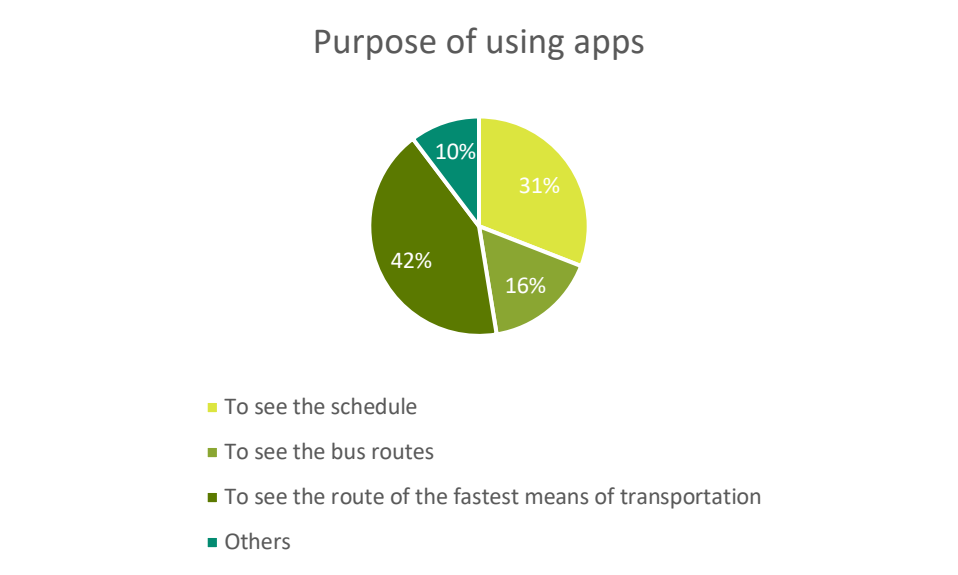


Figure 26 - Purpose of using apps

The following graphics correspond to the assessment of existing applications that users use most, according to several factors: utility, easiness (in terms of usability), design, security (personal data) and costs. In terms of utility (Figure 27) users think that these apps serve its purpose, but in terms of easiness (Figure 28) it could be a bit better build up. The participants feel that the design of the apps (Figure 29) can be improved. In the area of security of their personal data (Figure 30) they are neutral. And finally, in costs (Figure 31) they are very satisfied, since most apps are free of costs.

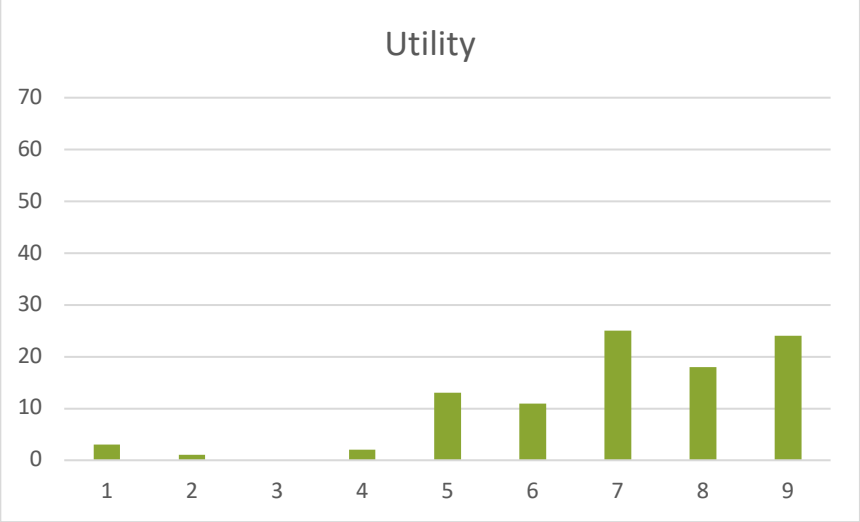


Figure 27 - Evaluation of the utility of the apps

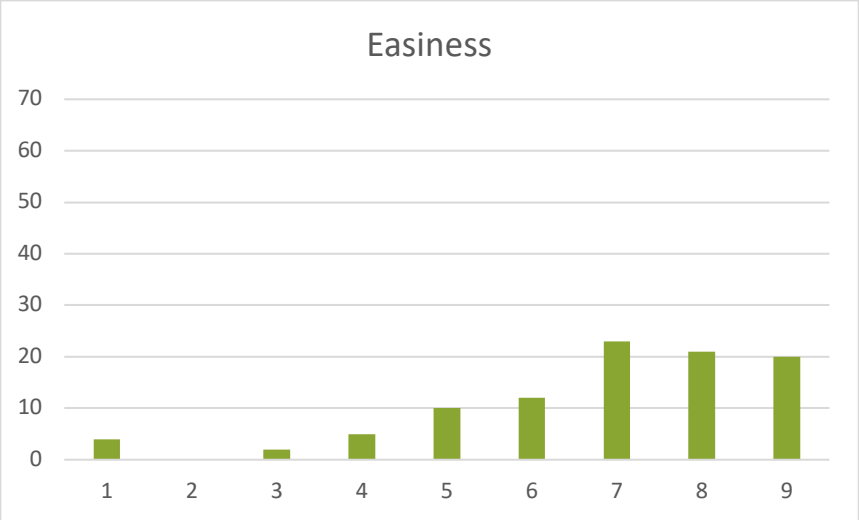


Figure 28 - Evaluation of the easiness of the apps

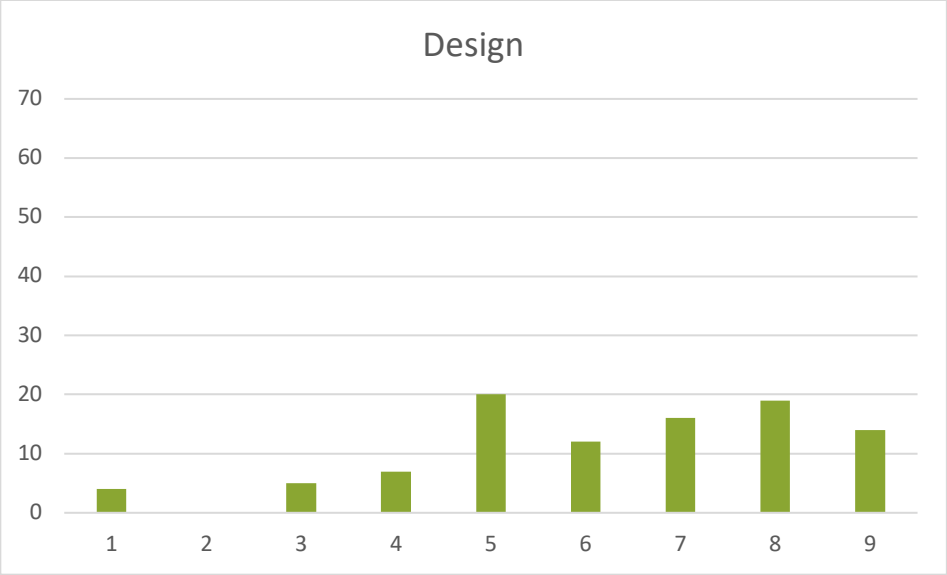


Figure 29 - Evaluation of the design of the apps

Figure 30 - Evaluation of the security (personal data) of the apps

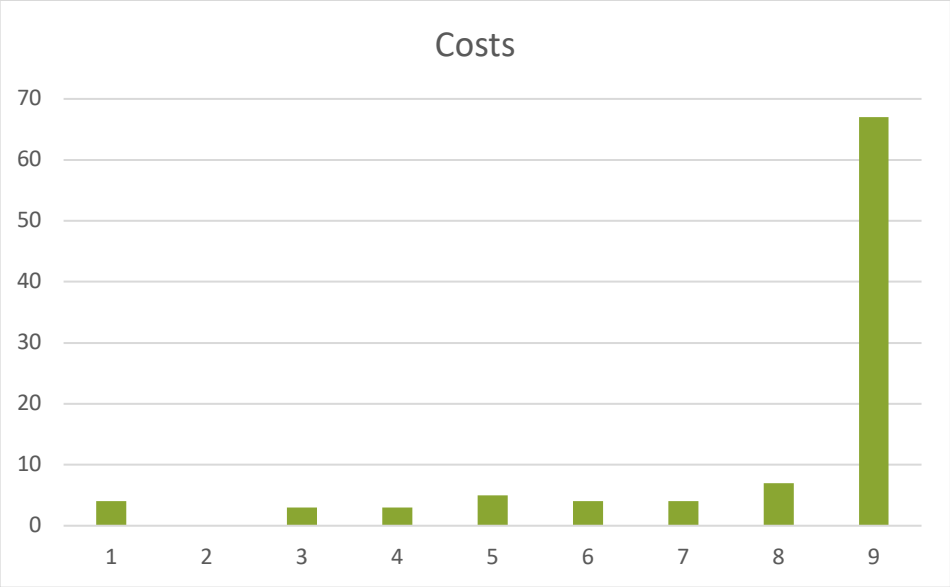


Figure 31 - Evaluation of the costs of the apps

4.2.4.4. Conclusion

The objective of the questionnaire was to collect and analyze the data about mobility, the utilization of public transportation namely buses, the main problems in buses and the use of apps associated with public transportation in 3 sections: sociodemographic, public transportation and apps.

The majority of the participants to this questionnaire were women with ages between 20 and 30 years old, with higher education and living in Lisbon. The questionnaire showed that most of the participants use car in a daily basis. However, the age group between 30 and 40 years old prefer to use public transportation, namely metro. The study revealed a lot of problems with buses like frequent delays, lack of seating and the frequency of buses which lead the participants to not use buses. The results also showed that the majority of the participants don't use the text message available on the bus shelters to track the bus, however they use other applications like Google maps. The participants believe that the apps could be improved in terms of easiness and design.

In summary, most of the inquired people do not use public transportation. The ones who use show several glitches in these means such as buses. In terms of the existing applications for helping the use of public transportation most of the people don't know any, but the most known and used one is Google maps by far. And finally, it is obvious people are not completely satisfied with the

existing apps. Overall, improvements can be made in the functioning of bus (where there are a lot of problems and dissatisfaction) and in the main considering their design.

The results of the questionnaire were used to build three personas (Maria, Pedro and Joana) and one antipersona (Ricardo) as well as their user journeys.

4.3. Personas and User Journeys

This section is based on the previous one. With the data collected from the questionnaire it was possible to build three personas and one antipersona and their users' journeys.

The personas are created centered on previous research, in this case based on the answers of the questionnaire. They are fictional characters that speak for the different types of users that might use the product, service, site or brand that is being created. The creation of personas help designers understand the user's experiences, goals, behaviors and needs (R. Dam & Siang, 2021).

Figures 32 to 34 represent the 3 primary personas that were and Figure 35 represents an antipersona. Each persona and antipersona were created based on the questionnaire in its first section, the sociodemographic data, in the second section that refers to public transportation and in the third section that refers to applications. In the first section of the questionnaire the following data was retrieved: gender, age, city, county, educational level and professional occupation. In the second section of the questionnaire the following data was retrieved: the usage of a car on a daily basis, the most used routes during the week, the usage of public transportation, the problems associated with buses and the reasons that lead people to not use them. In the third section of the questionnaire the following data was retrieved: knowledge of applications that facilitates the use of public transportation, most used applications, the reasons for not using

applications and which improvements could be done to the existing applications.

Figure 32 - Persona Joana

"I don't know where exactly the bus is."

Maria, 21 years.

Single, no kids

Architectural student in the last year of degree in Ajuda

Lives in Mouraria, in Lisbon

Sculpture, Music, Nature, Love animals (mostly Dogs)

Vegan

Bio

She is a student that lives in Lisbon and studies in Lisbon. Maria always takes the bus or to go to college or to wanderin Lisbon. To help make her day-to-day journeys she uses an app, but she always misses the bus because it is late or the schedules are not updated. For once in her life Maria wants to be sure that she isn't late for college.

Personality

Extrovert

Adventurous

Autonomous

Delicate

Responsible

Environmentally conscious

Goals and motivations

- Have something to remind her that the bus is coming;
- Not to be late when she goes to college;
- Pay the pass in a way that she hasn't have to leave her house.

VS

Frustrations

- Missing buses due to Wrong schedules;
- Have to leave the house to pay her pass;

Figure 33 - Persona Maria

"I can't take my son to school using buses, because there's not always a place to sit him."

Pedro, 34 year

Married, a six year old kid

Civil engineer in a large company in Entrecampos.

Lives in Encarnação neighborhood

Environmental activism
Cross Fit, Nature, Video Games

Mediterranean diet

Bio

He is a civil Engineer that lives in Lisbon and works in Entrecampos. Two to three times a week he has to take his kid to school and in those times he chooses the car as transportation because it's rare to get a seat on the bus for his son. In the other times he goes to work and catches the bus, to help him in his day-to-day journeys he uses an app.

Personality

Positive

Resposible

Modest

Nice

Environmentally conscious

Cooperative

Goals and motivations

- Use the car only at weekends;
- Always have a seat on the bus;
- No more morning stress in the rush hours.

VS

Frustrations

- Not having, always, a seat available on the bus;
- Parking and gasoline price when has to take the car.

Figure 34 - Persona Pedro

Figure 35 - Antipersona Ricardo

User journeys are research tools that help to understand the process of a user finding a service or product and visualize if the design fails or meets to the user's needs over time (Interaction Design Foundation, n.d.). The user journey is composed by 5 elements, but only 4 were used in

this case to make the process more linear: an actor; scenario + expectations; journey phases; actions, mindsets and emotions; opportunities (Gibbons, 2018). The actor is the persona that goes through the journey. The scenario expresses the specific situation that the user journey approaches and it is associated with the persona's needs and goals in the situation. Are the main stages of the user journey, they supply the planning for the remain information in the user journey like thoughts, actions and emotions. The persona goes through behaviors, thoughts and feelings along the user journey and they are mapped in each user journey phase. The opportunities were not used in the Figures 36 to 39 but they are perceptions obtained from the mapping process and they report how the user experience can be improved. All of these steps all the brands to know more about the target users (Interaction Design Foundation, n.d.) and aligns a mental model for the whole design team (Gibbons, 2018).

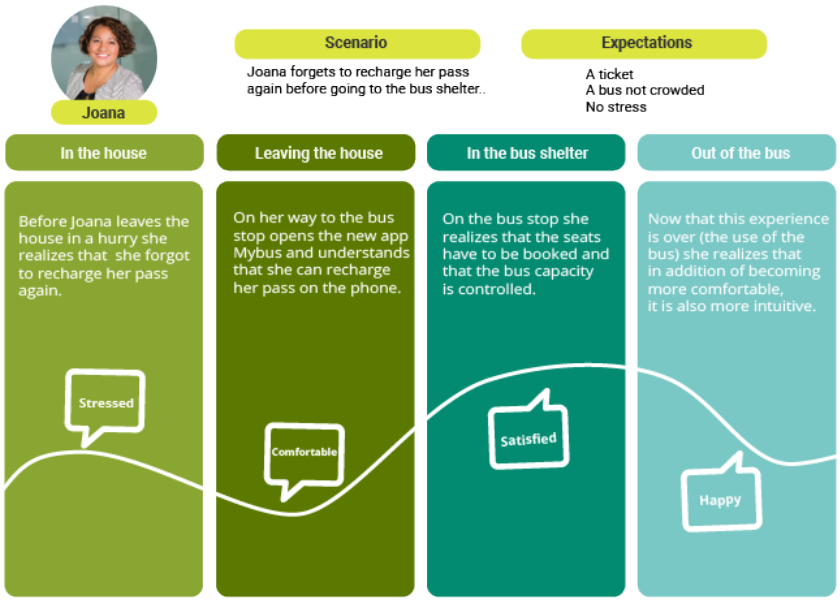


Figure 36 - Joana's user journey

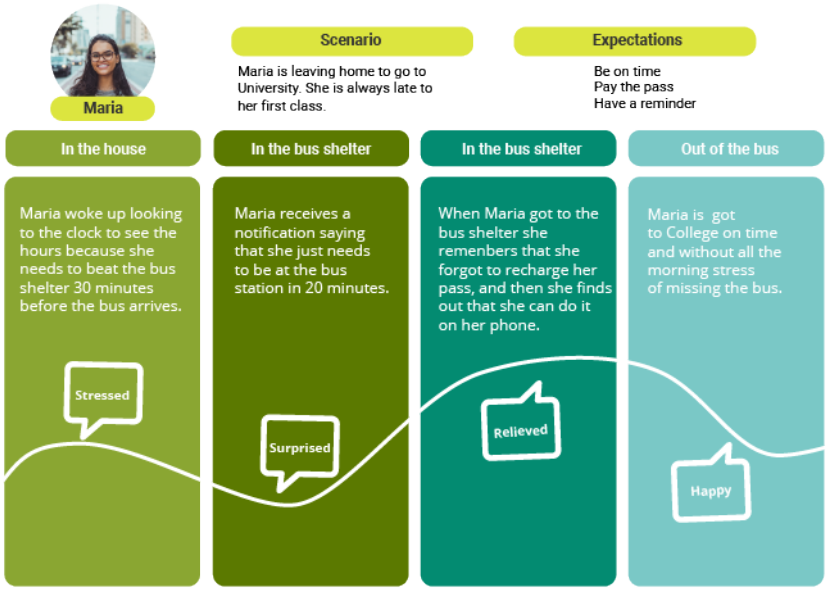


Figure 37 - Maria's user journey

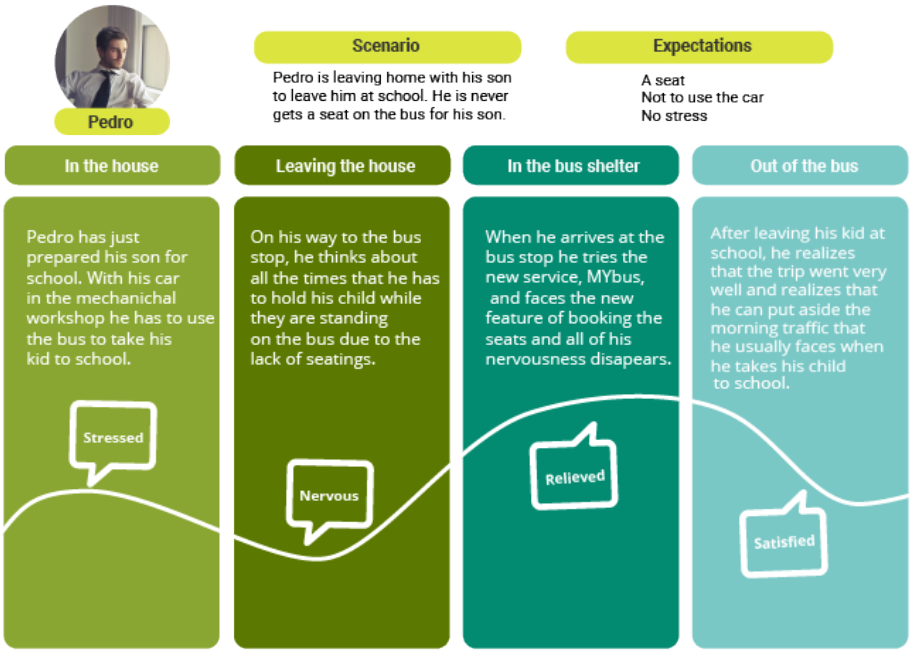


Figure 38 - Pedro's user journey

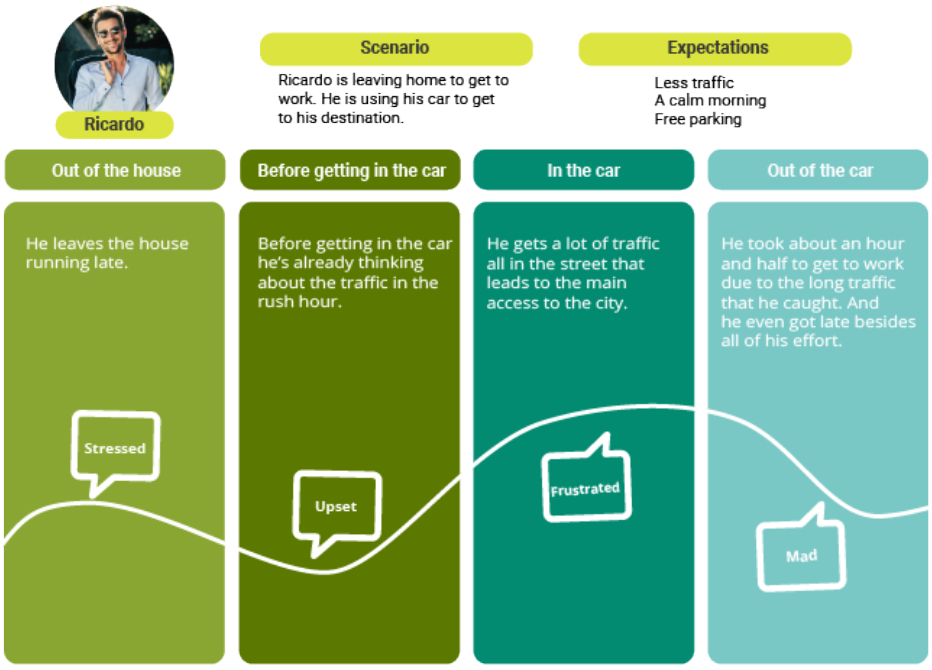


Figure 39 - Ricardo's user journey

The obtained results from the questionnaire were essential to build the personas, antipersona and their users' journeys. From the personas was possible to understand the target and identify the main problems with the buses. From the user journey was possible to comprehend how the target would feel using a new solution Mybus. All of this process is crucial to the ideation process that is described in the 4.5 (Phase 3: Development and Evaluation) section. The next section presents the navigation plan that had into account the personas and their user journeys.

4.4. Navigation Plan

The navigation plan assists to organize and determine the best information hierarchy. To a good interface is necessary to have an information architecture that knows how to balance between the needs of the user and the needs of the producer (Murphy, 2000). With this in mind two navigation plans were build: one for the smartphone application[5] (Figure 40) and one for the bus shelter platform (Figure 41).

[5] Presented in the appendix E in a bigger scale.

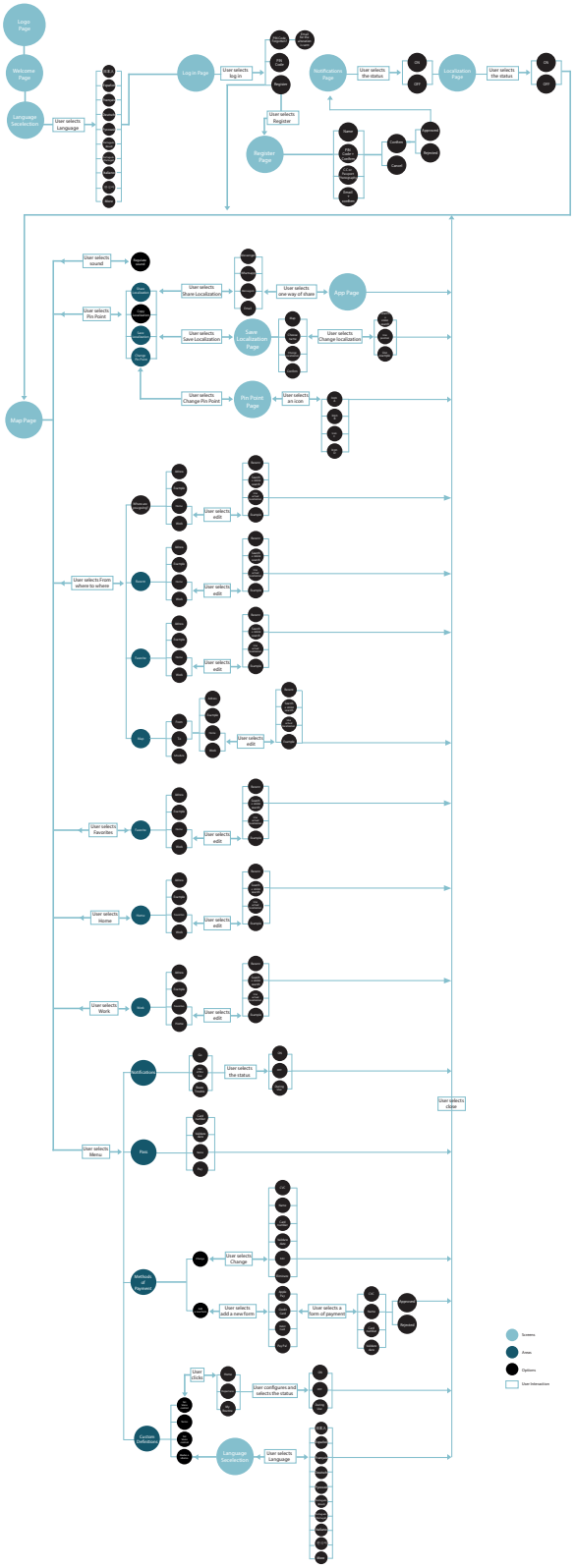


Figure 40 - Navigation Plan of the smartphone app

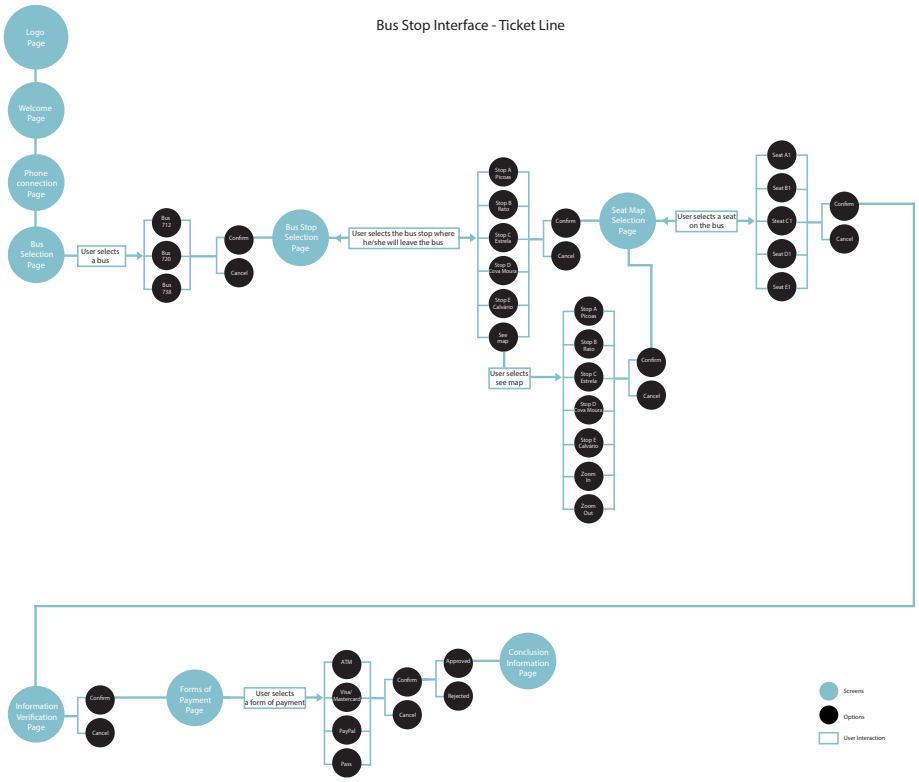


Figure 41 - Navigation plan of the bus shelter platform

In order to verify the hierarchy of information, presented in these two navigation plans, the next section is dedicated to this verification starting with the card sorting test.

4.5. Phase 3: Development and Evaluation

4.5.1. Project Definition

The Mybus system was thought and built for a smart city. This project concerns the problems of the buses and bus stops, which were discovered in the previous questionnaire (section 4.2). Mybus is an ecosystem that connects the user with the bus stop and with the bus itself. The ecosystem is divided between the bus, the bus stop and its platform, and also the smartphone application. Through the smartphone application it is possible to interconnect the bus stop and the bus itself.

Figure 42 shows the Mybus ecosystem: on top is the bus shelter and its platform, the bus on the left, the users on the bottom and closing the ecosystem is the smartphone application.

Figure 42 - Mybus ecossystem

The project assumes that the bus (Figure 43) would become electric with solar panels on top would make the idea more sustainable and self-sufficient (IMT - Instituto de Mobilidade e Transportes, 2017). The bus would only have seated seats, as many of the questionnaire participants said that they do not use buses because they cannot get a seat. A platform at the entrance was thought which would work with NFC and confirm the passenger's ticket and their entrance. It would have an AI in case any passenger needs to ask something. On the bus, it is important that there is an intelligent sensor on the seats so that it counts passengers, this would allow whether it is possible or not to pick up more passengers. People who are waiting at the bus stop can follow this information and know where the bus is in real time. This would be done by a built-in GPS so that the bus can transmit its location.

Figure 43 - Mybus proposal for buses

In the case of the bus stop (Figure 44) it would have at the top it would have solar panels so that it can energetically sustain the interactive advertisements (Ericcson, 2015) and, also, the information panels with information (Shamalinia, 2017) such as the timetables, routes and where the bus is in real time. The touch-operated glass platform at the stop would work through the interconnection with the smartphone application. Through NFC, the user touches his/her smartphone to the glass that detects the user's profile and associated information such as the method of payment. From this point on, the user can choose their seat and which payment method they want to choose to pay for their ticket. With the choice of seats, it is possible to control how many people intend to use the bus and so, if the bus is full, the central has the information it needs to send another bus.

Figure 44 - Mybus proposal for bus shelters

The smartphone application (Figure 45) allows the user to define routes and schedule trips, choosing which buses to use. The user can pay for his/her pass every month without having to go to an ATM or a kiosk.

Figure 45 - Mybus proposal for the smartphone app

In short, with the association of the smartphone to the bus stop platform, it is possible to provide more information to the user without feeling the need to leave his home.

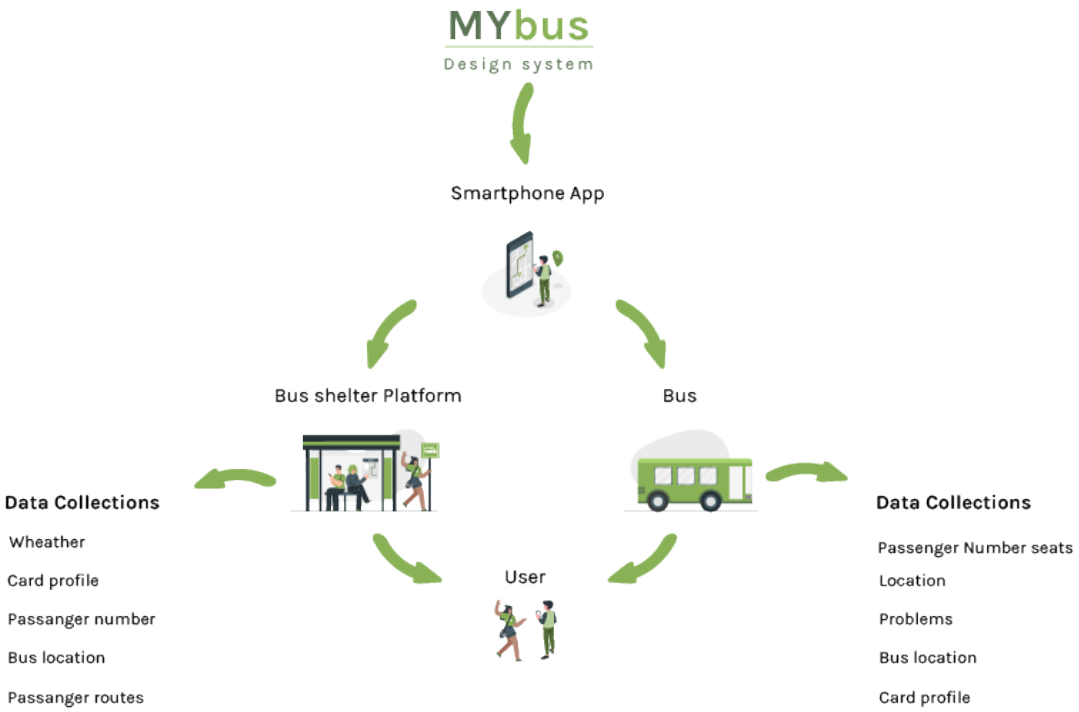


Figure 46 - Mybus data collection system

Figure 46 summarizes the contents from the following tables that describe the data collection (Table 1) and the necessary technology to collect them (Table 2).

Table 1 - Data collection for the bus

Data collections	**Tech**
Number of passenger seats	Sensors on the seats
Location	GPS (Global Positioning System)
Problems (e.g. Where should I leave?)	AI (Artificial Intelligence)
Card profile	NFC (Near Field Communication)

Table 2 - Data collection for the bus shelter platform

Data collections	**Tech**
Weather	Air conditioner
Passenger numbers	NFC (Near Field Communication)
Bus location	GPS (Global Positioning System)
Card profile	NFC (Near Field Communication)
Passenger routes	NFC (Near Field Communication)

4.5.2. Card sorting

The card sorting test has the objective of verifying if the information hierarchy on the system is correct. With this in mind, two card sorting's were carried out: one for the smartphone application and another for the bus shelter platform.

4.5.2.1. Method

The card sort is best understood not as a collaborative method of creating navigation, but as a tool that helps us understand the people for whom a product or service is being designed (Spencer, 2009).

Card sort is a frequently used method in order to inform or guide the development of a product's information architecture. It can also provide information on how to organize displays or controls on the interface (Baxter et al., 2015).

To conduct this technique, each participant must have cards that describe objects or concepts of a product in significant groups. By adding the order created by the test participants, it is possible to learn the level of relationship that exists between each of the concepts. Thus, it tells us how the resources of a product must be structured to meet the expectations of the users (Baxter et al., 2015).

This method shows how people think content should be organized and named, and is often used to generate a hierarchy of information. This refers to the organization of the structure

and content of a product, to the labeling and categorization of information, and also to the design of navigation and research systems. Good architecture helps users to find information or items, performing their tasks with ease. Since information architecture focuses on three concepts: “organizing content or objects”, “describing them clearly” and “providing ways for people to reach them” (Spencer, 2010).

Card sort involves writing content on cards, which is supposed to be found in the final product. The test participants are asked to classify the content into groups that make sense to them. It should be taken into account that there are no right nor wrong groups, since the groups that are formed are usually the ones that already exist in the heads of the participants (Baxter et al., 2015).

Within this method we can still define whether we want a type of card open or closed and with printed or computerized letters.

In an open card sort, participants generate the categories they want and name them. When closed, participants receive a set of cards and a set of predetermined categories and are asked to place the cards in these pre-existing categories. Open card sorts have more benefits, since, first, participants have more flexibility to express how content is grouped, reflecting an intuitive grouping; secondly the participants are asked to provide names for the groups they create, obtaining even more results. Due to these reasons, open tests are more directed towards the beginning of the research process and a closed test for an existing product in which the information architecture is to be improved (Baxter, 2015).

In a computerized card sort, time can be saved during the data analysis phase, since the cards are saved, however, it is also necessary to explain to participants how to use the software and can be complicated for some people who are inexperienced (Baxter, 2015).

For this test it was used a closed card sorting due to the fact that the test was made during the covid-19 pandemic leaving some limitations, like being online and not in person.

4.5.2.2. Participants

To run a card sorting test are needed at least fifteen participants (Nielsen, 2012). The test took into account twenty participants with ages ranged between 20 years old and 60 years old, corresponding to 12 women and 8 men. Three of the volunteers had experience in the design area, more specifically in the interaction design are, the others had no experience in any area of design.

4.5.2.3. Tools

Trello was used to collect data. It is a collaboration tool that allows to organize boards (https://trello.com). With this tool it was possible to invite the participants to collaborate in a board created with the test permitting them to organize the cards into the categories. This tool was used due to the coronavirus pandemic. The participants needed a computer to apply the method.

4.5.2.4. Procedure

The participants received two links (one for the smartphone app and one for the bus shelter platform) for the test by email. They were given 22 cards ("Name", "PIN Code forgotten?", "PIN Code", "Register", "PIN Code + Confirmation", "Photography of CC or Passport", "Email + Confirmation", "Português", "English", "Español", "Français", "More", "Notifications", "Pass", "Methods of Payment", "Custom Definitions", "Where are you going?", "Recent", "Map", "Home" and "Work") to be organized in 5 categories corresponding to the main features ("Log in Page", "Register Page", "Language Selection", "Menu" and "Map page") of the smartphone app. For the bus shelter platform 18 cards ("Bus 712", "Bus 720", "Bus 38", "Stop A Picoas", "Stop B Rato", "Stop C Estrela", "Stop D Cova da Moura", "Stop E Calvário", "See Map", "Seat A1", "Seat B1", "Seat C1", "Seat D1", "Seat E1", "ATM", "Visa/Mastercard", "Paypal" and "Pass") were given to be organized in 4 categories ("Bus selection", "Bus stop selection", "Seat Map selection" and "Forms of Payment"). The cards and categories were decided according to the Navigation Plan[6]. The procedure took place in two steps:

a) Step 1: The links. The links for the tests were sent by email with the description of the task.
b) Step 2: Task Analysis. The users had to complete the tests given in order to evaluate the hierarchy of the platforms.

4.5.2.5. Results and discussion

The errors presented in the tests[7] show that the most misplaced card in the bus shelter test was the "see map" card, with 20% of the participants getting it wrong, in second place was the card

[6] Navigation Plan presented in section 4.4.
[7] Table with the results presented in appendix F.

“pass” with 5% of the participants misplacing it, and in last “Bus 720” and “Bus 712” with 5% of the participants misplacing it. In the smartphone test, the most misplaced cards were: “More” with 60% of the participants getting it wrong; “Home” with 40% of the participants getting it wrong; “Pass” with 35% of the participants getting it wrong; “Map” with 35% of the participants getting it wrong; “Favorite” with 30% of the participants getting it wrong; “Register” with 25% of the participants getting it wrong; “Name” with 25% of the participants getting it wrong; “PIN Code” with 10% of the participants getting it wrong; “Work”, “Custom definitions” and “recent” with 10% of the participants getting it wrong; “Methods of payment”, “Notifications”, “Where are you going?” and “Photography of the C.C. or passport” with 5% of the participants getting it wrong.

Analyzing the errors in the bus shelter platform test it is possible that the three errors, with a 5% rate of error, could be due to distraction on the part of the participants, since these errors were made by the same participant. However, the error on the card “see map” may be due to the fact that this card is more ambiguous as it could be associated to see the map of the seats on the bus or see the map of the bus stops.

Analyzing the errors in the smartphone app test it is possible to understand that are some cards that are a bit ambiguous. The “More” card was misplaced in the “Menu” category, which could mean see more options of the menu, and in the “Map page” category that could also mean see more options in the map. The “Home” card was misplaced in the “Menu” category as it could mean that the participants interpreted that home was the button to return to the home page and not the button with the user's address. The “Pass” card was misplaced in the “Log in page” category by 30% of the participants and in the “Register page” by 5% of the participants, this may be due to the fact that participants think they could log in or register with the pass. The “Map” card was misplaced in the “Menu” category since maybe the participants thought it would be possible to see the map only with the bus stop in the menu. The “Favorite” card was misplaced in the “Menu” category in this case perhaps the participants thought that they would be able to access their favorites through the menu and not use their favorites like predefined trips and places. The rest of the misplaced cards with lower percentages of error, between 25% and 5%, could be due to distraction on the part of the participants.

4.5.2.6. Conclusion

The errors found in the bus shelter platform have a lower rate, which make them not problematic problems. However, the “see map” card is the only card that it is very ambiguous and has to change for the next test. In the smartphone app test the most urgent error is the “More” card that is very ambiguous as it is possible to insert it in more than one category and still make sense. The same happens to the major part of the other cards, the names have to change so they aren’t so ambiguous. In the phase 4 it will be possible to evaluate the conclusions retrieve in this section.

4.5.3. Interface design

Green is a secondary color composed by blue and yellow. The Blue part transmits peace and tranquility and the yellow brings warm and energy and the balance between these two colors create a stable effect (Black, 2002). The lighter greens are connected with energy and youth as in the other hand the dark greens are linked with security and prosperity. The use of the green is appropriate for designing for areas associated with renewal, nature, stability and wealth (Chapman, 2020). Therefore, the color for this application was green.

The logo (Figure 47) created for the ecosystem called Mybus is in green to be associated, by the users, to movement, ecology and sustainability (Black, 2002). The movement is associated with the daily lives of people who need to move around in their daily routines, ecology and sustainability are linked to the fact that if citizens use public transport means and not the use of private transportation, they can help the environment by reducing gases associated with fossil fuels.

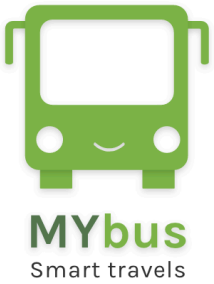


Figure 47 - Mybus logo

Two typographical families were chosen, for titles Karla (Figure 48) and for the text Helvetica Neue (Figure 49).

The Karla typography was chosen for being a sans serif as it gives a better legibility for screen purposes, and it is a round typography which confers a comfort and feminism. It was used in Bold instead of regular to become more legible in opposition to its roundness associated with feminism and the bold with masculinity (Kolenda, 2021). It was used in uppercase and lowercase in order to give a better readability.

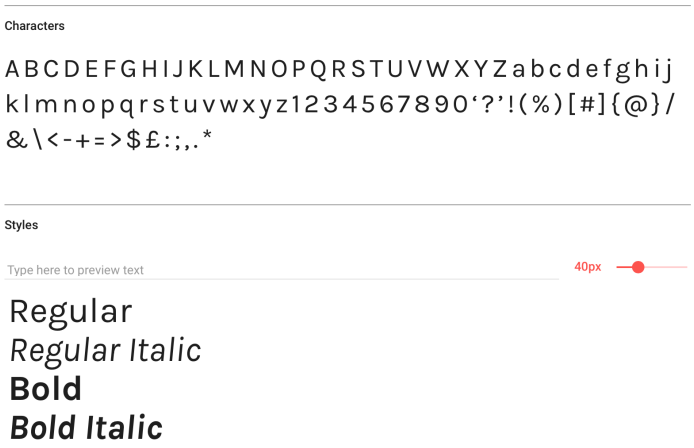


Figure 48 - Karla tipography family

As Karla, Helvetica Neue was used for being a sans serif and in opposition to Karla used in regular to contrast to Karla’s title use. And it is known for its improved legibility inside the Helvetica family which makes it a good typography for smaller text (Linotype, 2021).

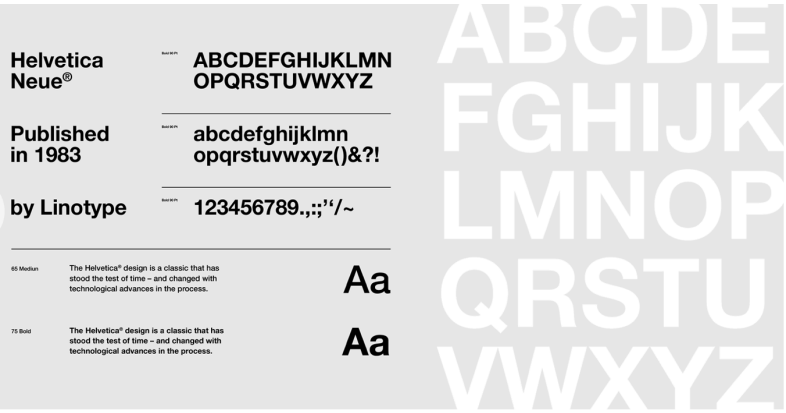


Figure 49 - Helvetica Neue typography

In conclusion the choice of the typographical families had in account the readability and legibility targeted for two screening platforms. In the next chapter it is possible to see the evaluation for the choice of the typographies and colors for this project.

4.6. Phase 4: Evaluation

Usability testing it is a great way discover the problems present in the project, to be able to learn more about the users' habits and selections and to improve the design. To run a usability test is needed a facilitator (or a moderator who runs the test), tasks (of the design that is being tested) and a participant (a person inserted in the target to perform the tasks) (Moran, 2019). The interaction between the facilitator and the participant is described in the Figure 50 (created by Nielsen Norman Group):

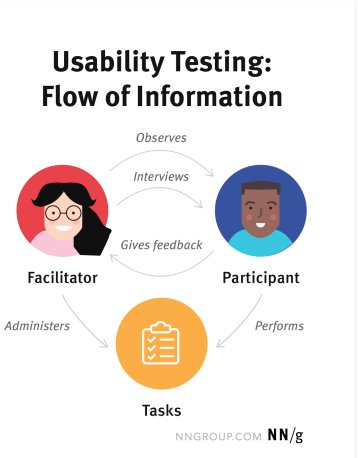


Figure 50 - Flow of information

4.6.1. Low Fidelity Prototype – Wireframes (User Testing – 1º iteration)

The main objective of this study is to test the low fidelity prototype with users. The user test will help to give a better insight where the project can be improved and it also helps to reveal the main flaws that it has.

4.6.1.1. Method

Moderated tests give the opportunity to the facilitator and the participant to talk during the test so allows the facilitator to ask questions during the test or afterwards the test for clarification (Schade, 2013). Moderated (also called synchronous) remote tests are very similar to a lab testing, but the major difference is the spatial distance, so the moderator and the facilitator are not in the same cohabitating space (Barnum, 2011).

The process think-aloud encourages the participant to shares his thoughts with the facilitator while interacting with the product (Barnum, 2011). This technique is also used for other purposes besides usability testing such as user research like in a card sorting or field studies (Baxter, et al, 2015).

The moderated usability tests offer the opportunity to interact directly with the test participant (chosen according to the target) for the platform that is being tested. These kinds of tests allow the facilitator a better insight on how to improve the project as well as the objectives that the users might have (Adiseshiah, 2019). These tests also used the think-aloud process.

The platform used for prototyping the tests and generate the links was the Adobe XD program.

Due to the pandemic crisis we live in, the moderated tests had to be remote with the help of the Zoom platform.

4.6.1.2. Participants

To run a moderated test at least twenty participants are needed (Nielsen, 2012). Twenty-five volunteers have participated in the study with ages ranged between 20 years old and 60 years old, corresponding to 14 men and 11 women.

4.6.1.3. Procedure

The procedure was given in the day of the tests as well as the links for the task analysis. The participants were given the tasks and the procedure with the purpose of completing it. In total 6 tasks were executed corresponding to the main features (register; search a bus to go on a trip; add a place to the favorites; recharge a pass; change or add a credit card and schedule a trip) of the phone app. For the bus shelter platform 1 task was given. The procedure took place in three steps:

a) Step 1: The procedure. The procedure was presented to the participants before beginning the test giving them time to read and to answer any questions. After the participants read the procedure, it was explained that the two platforms that they were testing were regarding smart mobility and how UX design could help it. The doubts left were clarified and it was explained to the participants that their participation it was voluntary and as such they could withdraw from the test at any time.

c) Step 2: Task Analysis. The users had to complete the tasks given in order to evaluate the navigability of the platform. The flow of each task is shown above in Figures 51 to 56. And the flow for the bus shelter platform in the Figure 57.

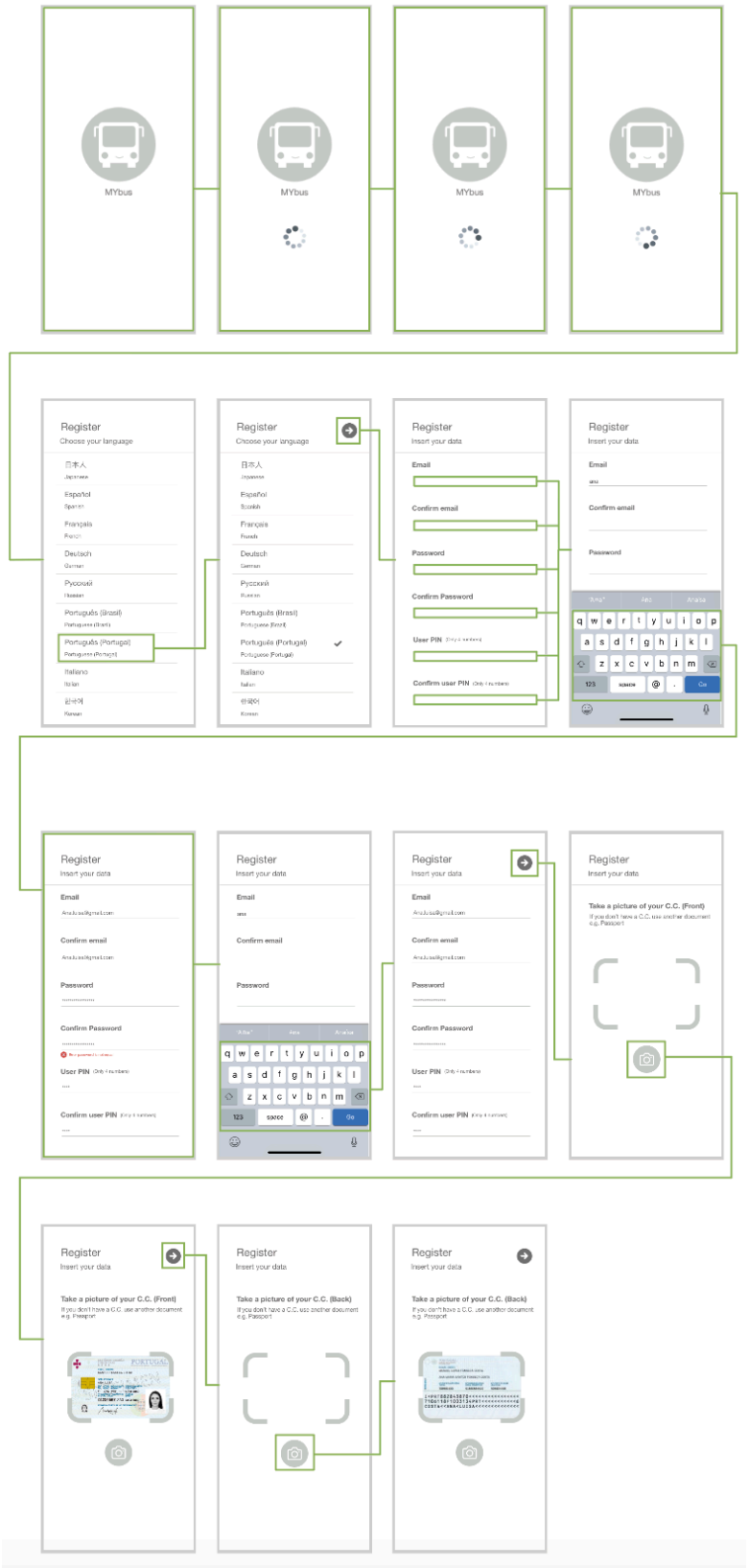


Figure 51 - Task 1: Register

Figure 52 - Task 2: Go home

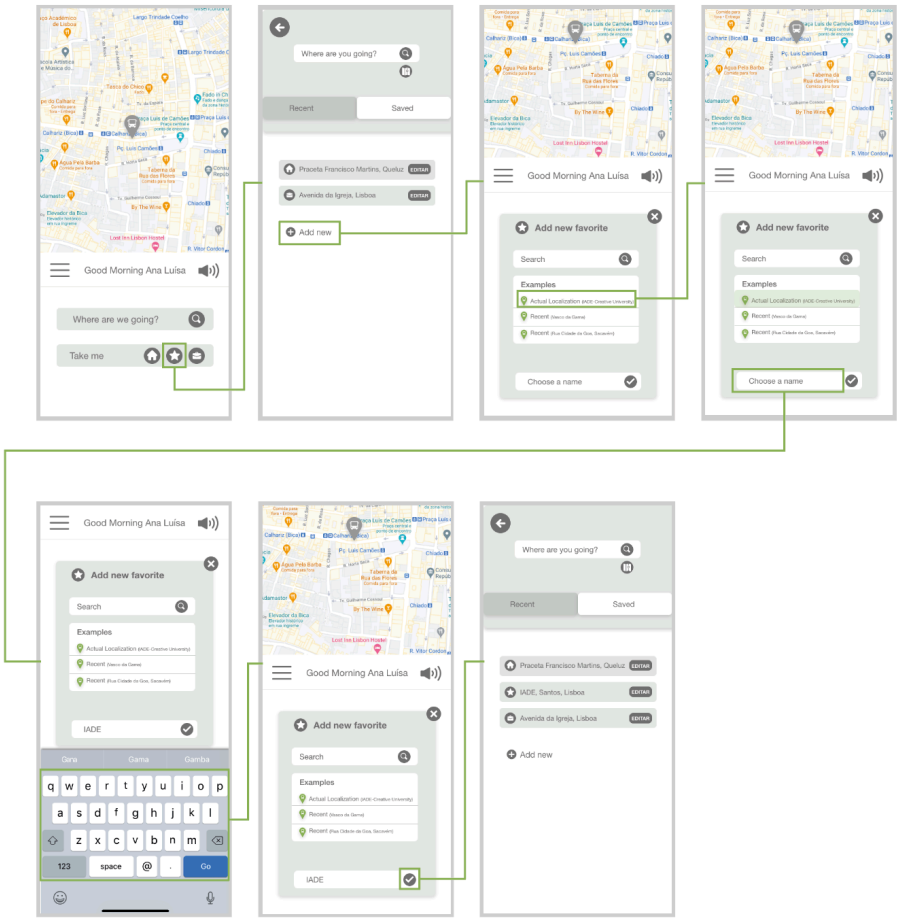


Figure 53 - Task 3: Add to the favorites

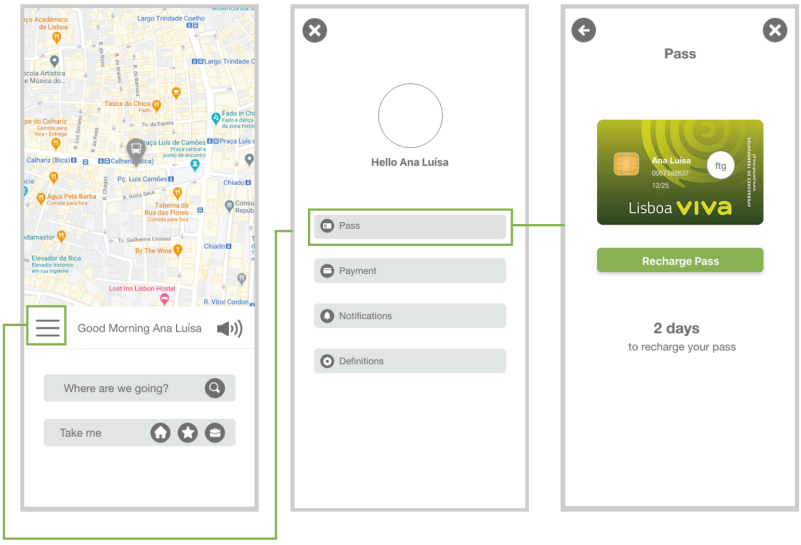


Figure 54 - Task 4: See your pass

Figure 55 - Task 5: Recharge your pass

Figure 56 - Task 6: Schedule your trip

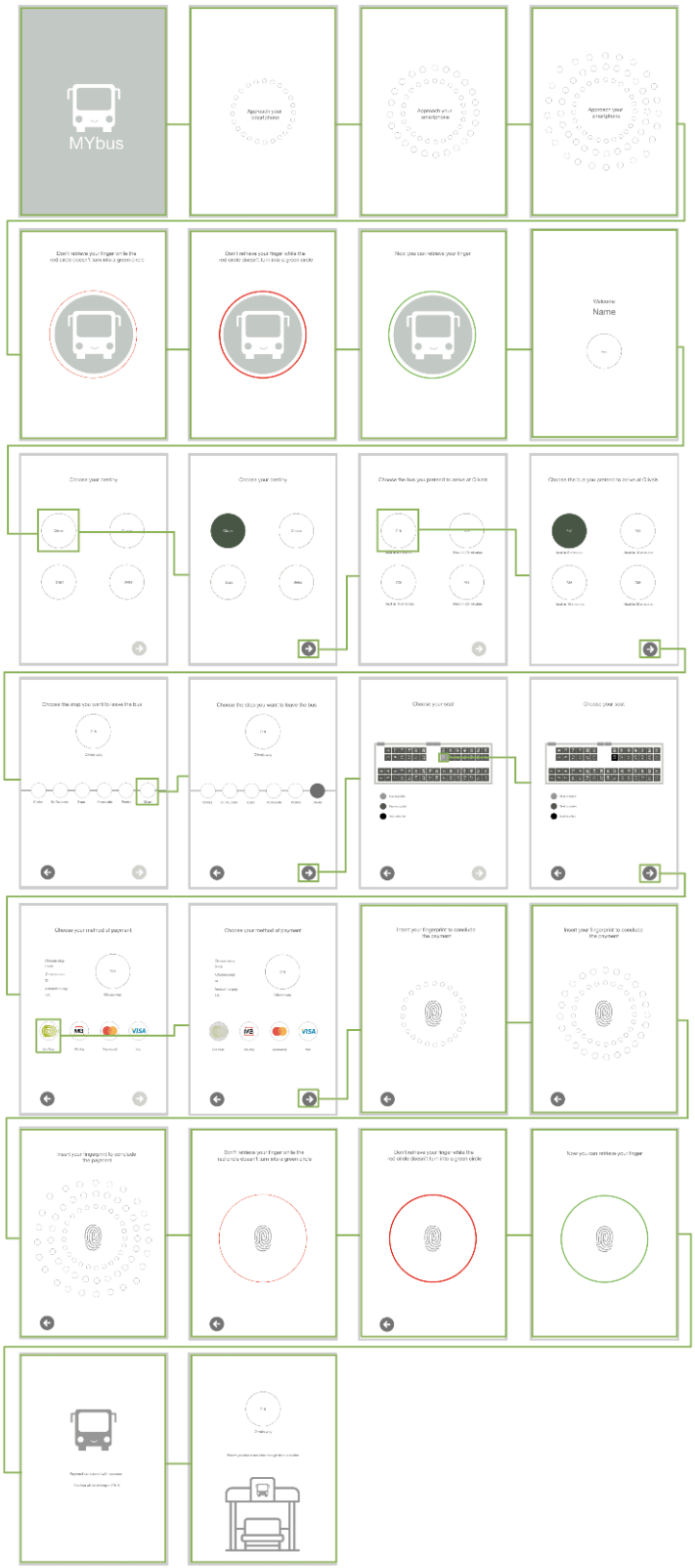


Figure 57 - Task 1: Buy a ticket

b) Step 3: Feedback. In the end of the tests the participants had to answer to a questionnaire[8].

4.6.1.4. Results and discussion

It was requested to the users to give a classification from 1 to 7 [9](1 is very difficult and 7 very easy) to classify the difficulty to each task that they performed. The average given to the tasks is shown above in the graphic (Figure 58).

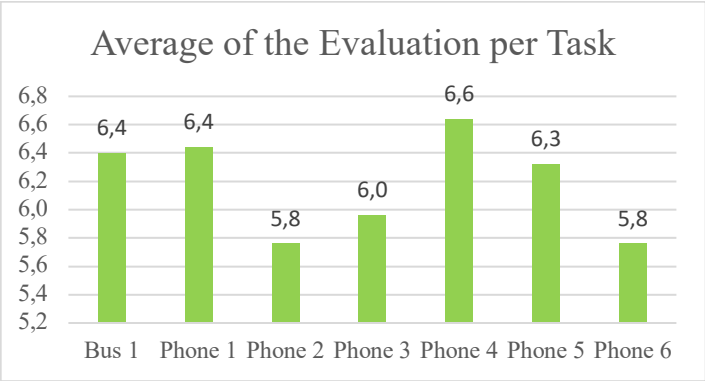


Figure 58 - Average of the evaluation per task

The tasks that the users had more difficulty to perform were the tasks 2 and 6 in the phone application. Those are the ones that must be redone.

Five questions[10] were asked in the questionnaire:

1- In the smartphone app, were there any icons, texts or colors that didn't make sense to you?
2- In the bus shelter platform, were there any icons, texts or colors that didn't make sense to you?
3- In the smartphone app, exists an option with the purpose of notify you about the bus's schedules, the time you must leave your house to catch the bus on time and others. Which are the notifications that make more sense to you?
4- What do you think about the color green being associated with the two presented platforms? Since they are about buses?
5- Do you think that both apps (for smartphone and for the bus shelter) need more or less content?

[8] Presented in the appendix G in Portuguese once it is destined to the Portuguese population.
[9] The table with the classifications per user is shown in the appendix H.
[10] The table with all the answers is shown in the appendix I.

In the first question, most of the users answered no (corresponding to 68%), but some users complained about the schedule trip button due to the size of the button and the lack of labeling. Also, one user said that couldn't understand why had to pay the pass in the "pass" and not in the "payment", the reason is to be more visible and quicker when the user goes to see the pass status. And last but not least, one participant said that having the C.C. as identification didn't make sense, which is agreeable and that's why will not be found in the next step the layout.

Most of the answers on the second question, corresponding to 72%, were no as well as on the first question. Three users were concerned about the color of the seat chart but it will be changed in the layout to more suitable colors.

When was asked to the users which were the most important notifications that they could receive the majority of them said that would be the time to leave the house to catch the bus on time and the second was to recharge the pass. Others were mentioned like the schedule of the buses, delays on buses, show the number of buses for the most used destinations, personalized time notifications (X time to catch the bus), alterations in the bus's routes, capacity of the bus and alerts to new buses.

All users, but one, agreed on the use of the color green for both platforms. The user that didn't agree thinks that the color yellow is better since buses are yellow. However, the color green is present in public transportation like the viva pass.

In the fifth question most of the users, corresponding to 72%, find the application with the right amount of content. Some said that could be an option that could show the delays on buses and some alternatives to those paths.

In summary, there are some tasks to be redone as mentioned above, some notifications that can be added and considerations about the booking of the seats if that make sense to keep or not.

4.6.1.5. Conclusion

The main concerns to change for the next test are labelling, size of the icons, removing C.C. as a main step of identification and add personalized notifications. The changes can be observed in the next section.

4.6.2. High Fidelity Prototype – Interaction Prototype (User Testing – 2º iteration)

The main objective of this study is to test the high-fidelity prototype with the users. The user test will help to give a better insight where the project can be improved and it also helps to reveal the main flaws that it has.

4.6.2.1. Method

In the unmoderated usability tests the participant is alone, so this doesn't allow for real-time interaction between the participant and the facilitator, but in the end can be some follow-up questions. These questions can also be emailed after the session is finished. During the session there isn't the possibility to ask the participant specific questions for their actions, so they don't have real-time support to clarify their doubts. So, it means that the facilitator doesn't know how was the session like until it has ended (Schade, 2013). Unmoderated remote testing is also called asynchronous and it can be accomplished with the help of applications that can capture the screen, navigation path, drop-off rates, keystrokes and others by collecting the data (Barnum, 2011).

To do this unmoderated test were used the Nielsen's Heuristics (Nielsen, 1994). There are 10 heuristics:

- H1 "Visibility of system status";
- H2 "Match between system and the real world";
- H3 "User control and freedom";
- H4 "Consistency and standards";
- H5 "Error prevention";
- H6 "Recognition rather than recall";
- H7 "Flexibility and efficiency of use";
- H8 "Aesthetic and minimalist design";
- H9 "Help users recognize, diagnose, and recover from errors";
- H10 "Help and documentation".

These heuristics are principles and guidelines to a good interaction design. With this norm in mind, it was asked the users to evaluate the two platforms presented in this work.

4.6.2.2. Participants

To run an unmoderated test five participants are needed (Nielsen, 2000). Five people participated in the study with ages ranged between 20 and 30 years old, corresponding to 2 men and 3 women.

4.6.2.3. Procedure

The procedure was sent by email to each participant[11]. It was constituted by the instructions, the tasks to perform, a heuristic evaluation table and the link to the interactive prototype. There were three steps to the procedure:

1. **Understand the objective of the study –** here the evaluators had to understand the process of the study and what was asked for them to accomplish.

2. **Do the task analysis –** in this step the evaluators had to perform the tasks that were asked. The task flow of the smartphone app is shown above from Figure 57 to Figure 62. And the task flow for the bus shelter platform is shown above in Figures 63 and 64. To do this test was only needed a computer and the procedure with the following links: (Bus shelter platform) https://xd.adobe.com/view/ff5fcf1a-5f60-4035-8d38-f8db5c4a165c-aa0c/?fullscreen&hints=off and (Smartphone app) https://xd.adobe.com/view/bffaa5a0-0801-41fb-b71f-2d9fbfdfb354-eaa9/?fullscreen&hints=off

[11] Procedure sent to the evaluators presented in the appendix J.

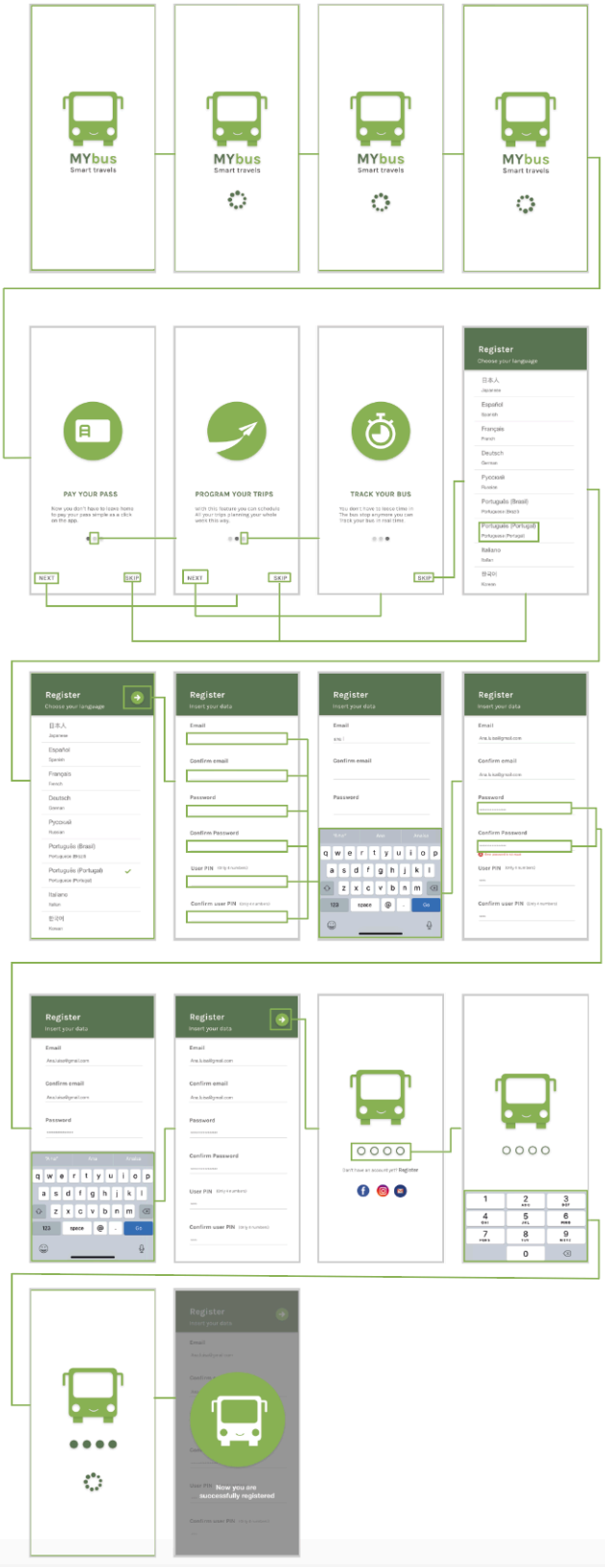


Figure 59 - Task 1 for smartphone

Figure 60 - Task 2 for smartphone

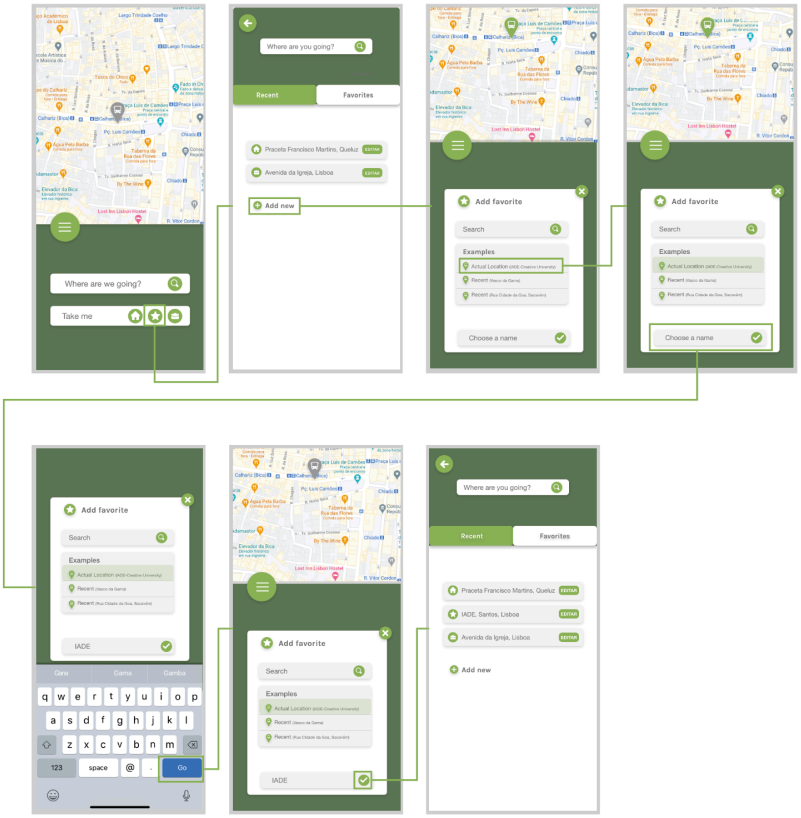


Figure 61 - Task 3 for smartphone

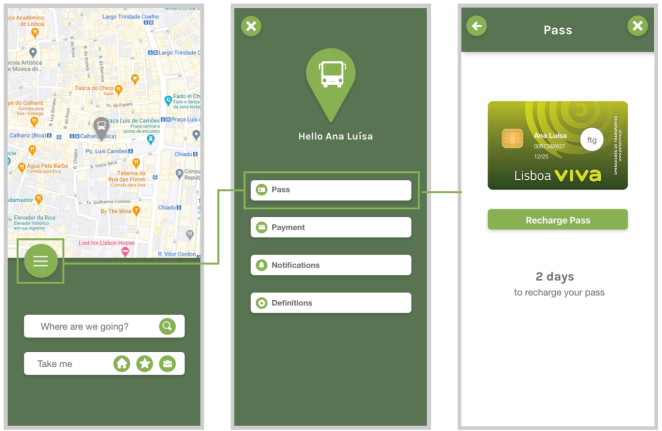


Figure 62 - Task 4 for smartphone

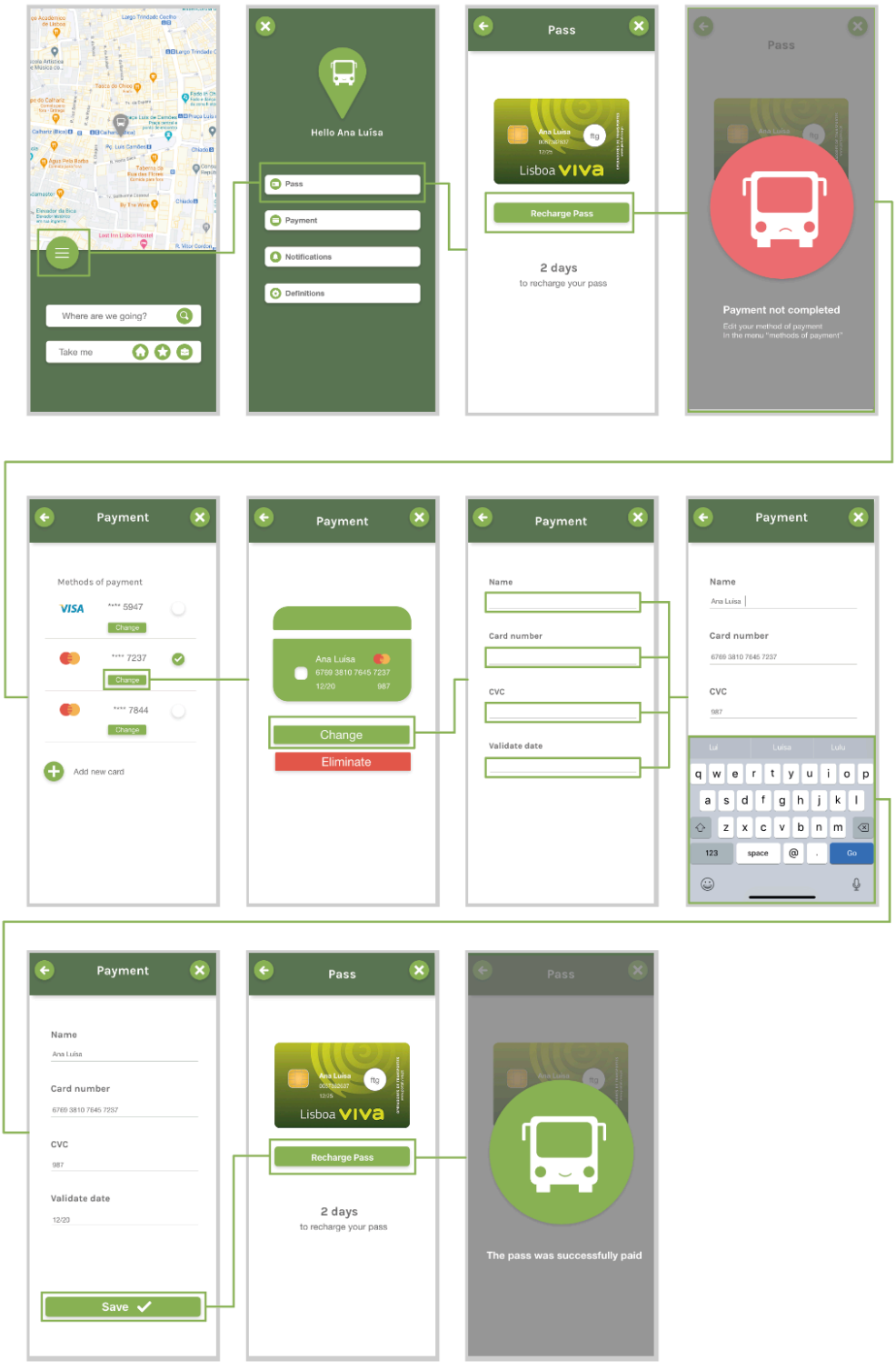


Figure 63 - Task 5 for smartphone

Figure 64 - Task 6 for smartphone

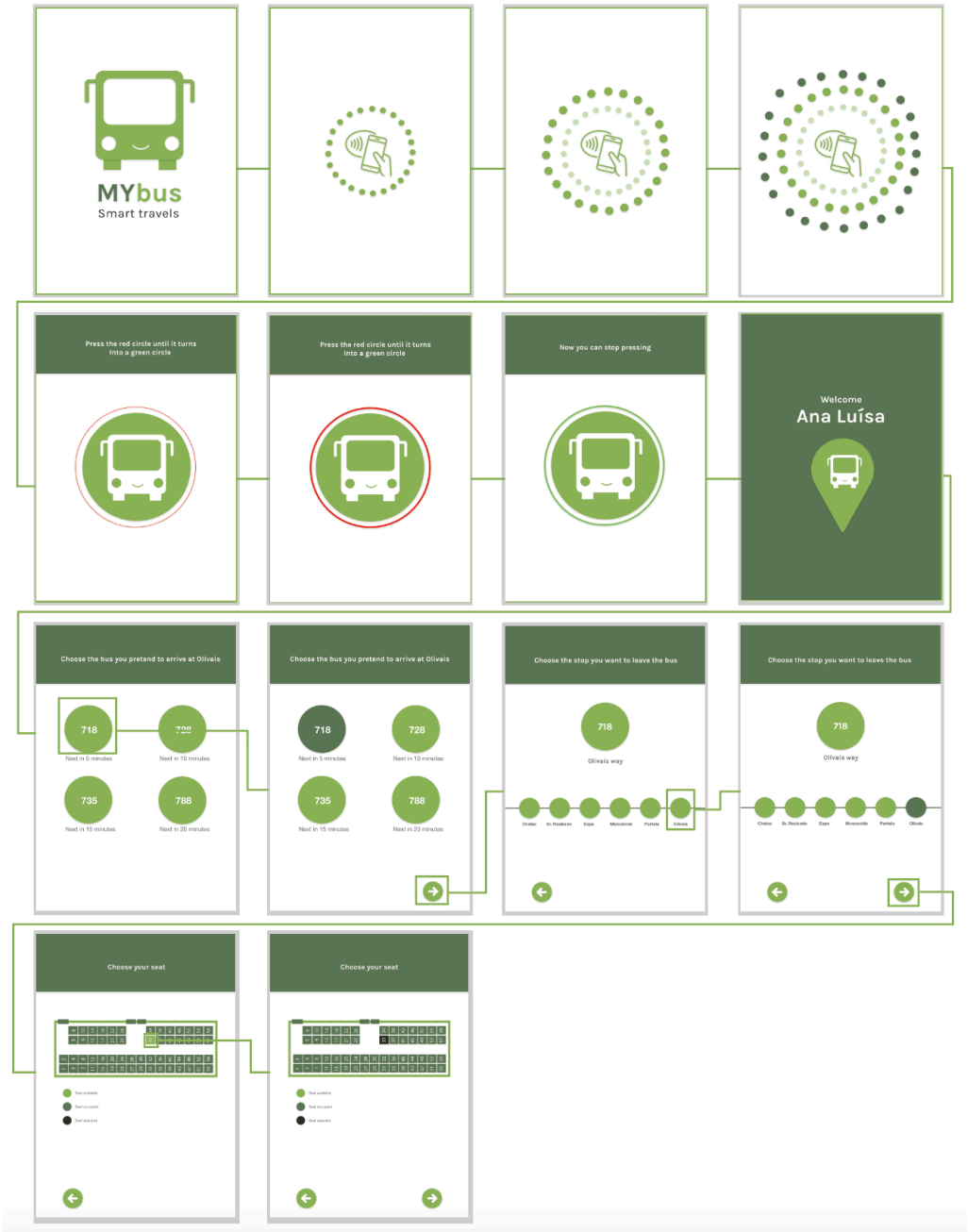


Figure 65 - Task 1 for bus shelter

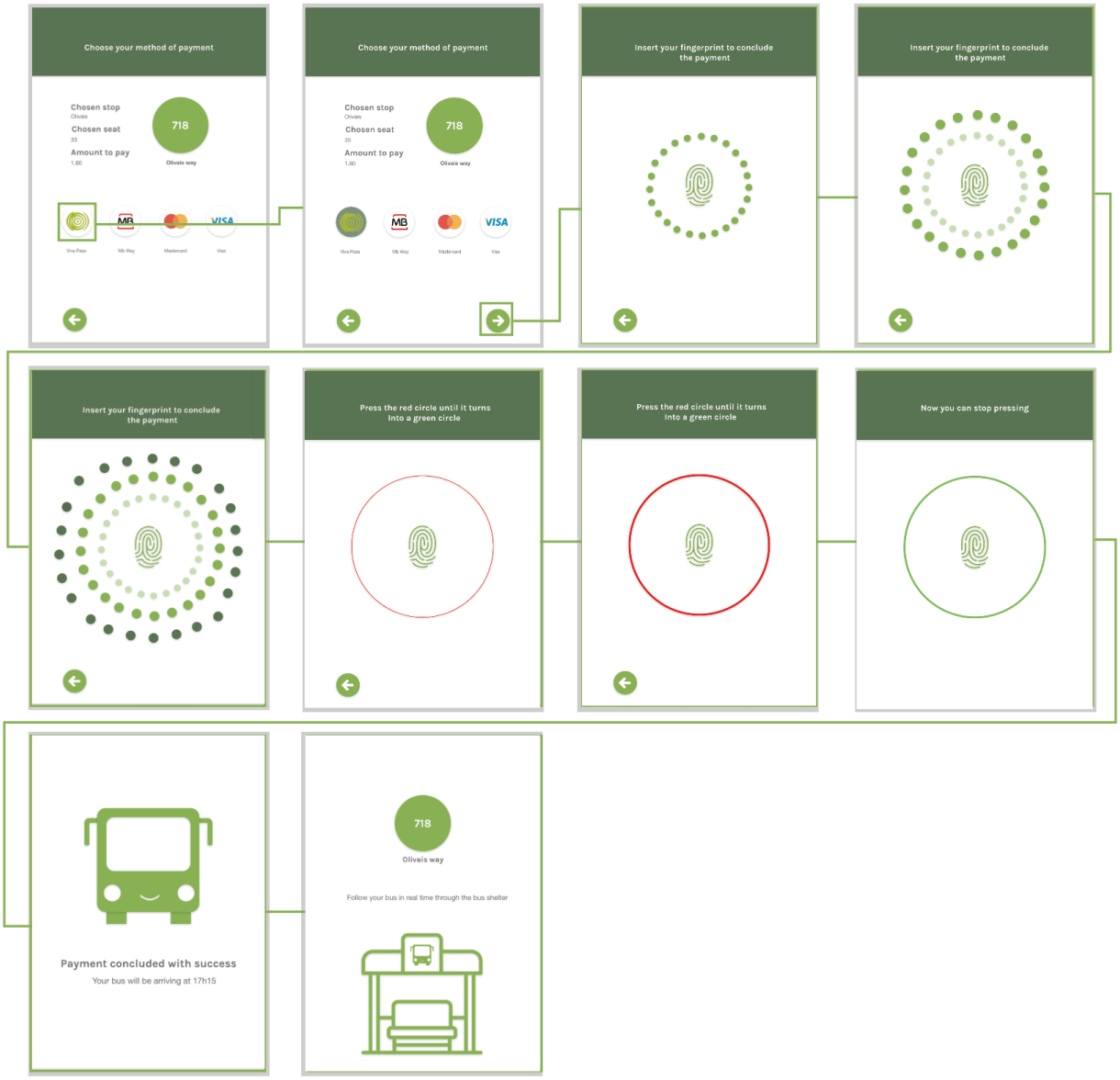


Figure 66 - Task 2 for the bus shelter

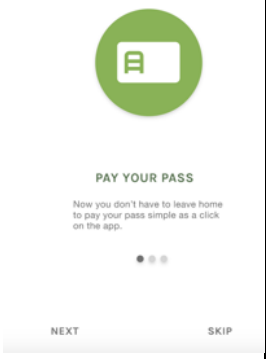
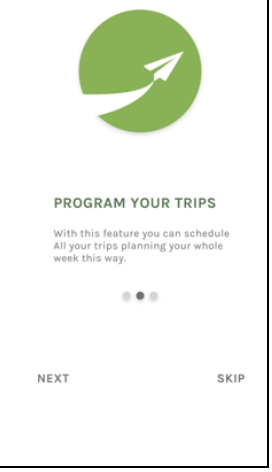
3. **Nielsen's 10 Heuristics** – In this final step the participants evaluated the two platforms according to the Nielsen's ten heuristics (Nielsen, 1994). They also gave to each problem a grade from the severity rate scale that begins in 0 = I don't agree that this is a usability problem at all, 1 = Cosmetic problem only: need not be fixed unless extra time is available on project, 2 = Minor usability problem: fixing this should be given low priority, 3 = Major usability problem: important to fix, so should be given high priority and 4 = Usability catastrophe: imperative to fix this before product can be

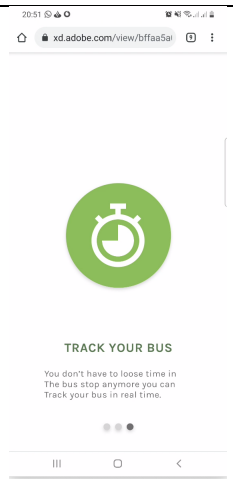
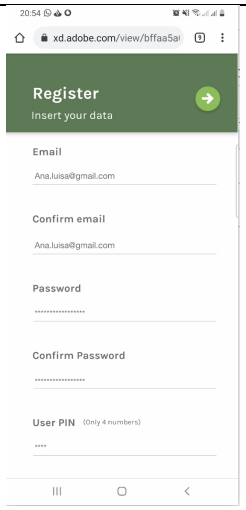
released (Nielsen, 1994). All these criteria were inserted in the table that was sent in the procedure to the evaluators.

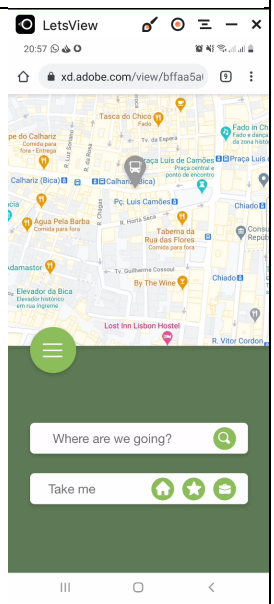
4.6.2.4. Results and discussion

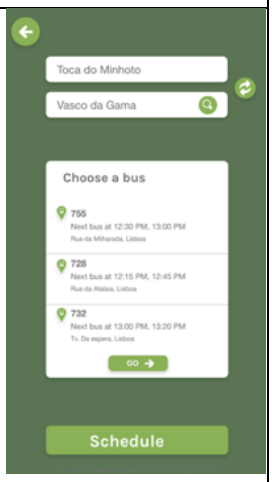
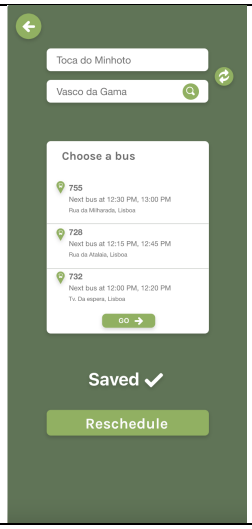
The heuristic evaluation was done by 5 experts in interaction design area which led to the following content tables 3 and 4:

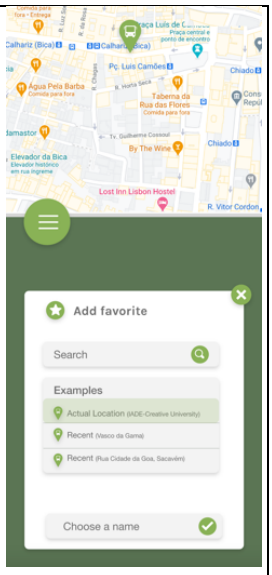
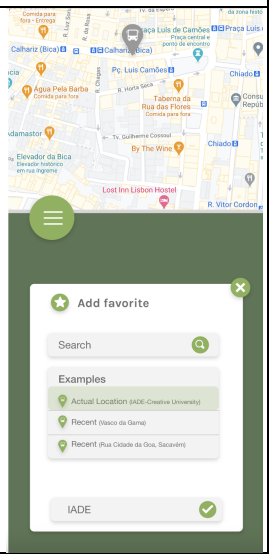
Tabela 3 - Table of the results of the heuristic evaluation for the smartphone app

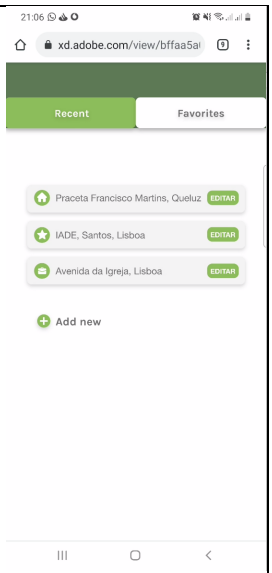
Task	Violated Heuristic	Severity Criteria	Problem category	Problem Found	Suggested Improvements	Screenshot
1	H6; H10	2	Labeling; Visual hierarchy	Skip are more prominent on the right. Onboarding won't be important, why give more value to "Skip"? The information on this screen should be more useful. Onboarding should be when entering the app with a login.	Give relevance to "next". Change the onboarding to after login, only on the first use of the app.	
1	H2	2	Labeling; Visual hierarchy	Is the image just illustrative, or should it communicate something? This image looks more like sending something than traveling. But still, the context is one of planning, which is different from just traveling.	Modify the information to something more precise. Modify the illustration if really necessary.	

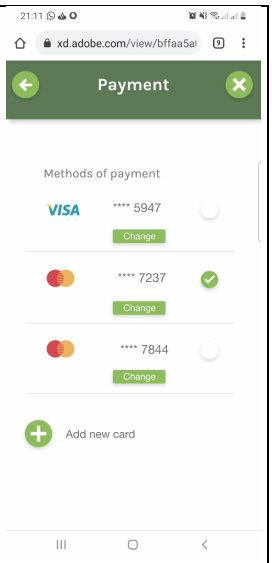
1	H3; H2	1; 2	Interaction; Labeling; Visual hierarchy	“Couldn´t find the “skip” or “next” on the screen”; “The text could have more relevant information. The illustration could be better. Is the button from Skip, or Finish?”	“When we don´t have the control of the device, we should choose a smaller screen size for the prototype. But this is just a tip, not something to improve on this prototype” “Modify the information to something more precise.”	
1	H3; H10	4	Interaction	“I choose the language after an onboarding in English, when I choose Portuguese, the app remains in English”	“Language should be one of the first things the user chooses.”	
1	H1; H5; H6; H9; H10	2; 3	Feedback; Interaction; Terminology	“Can´t recognize if the password is correct” “The main CTA appears at the top right corner. There are 2 problems here: 1st there’s not enough contrast between the green background and the green CTA and the CTA should be located closer to the finger radius, not on the top of the screen.” “PIN and password? Why do	“Use visual elements to show it´s correct” “Create more contrast between the background and the CTA, CTA needs to call the user to act. The main CTA should be located at the bottom of the screen, where it’s easier for the user to interact. (And has more contrast because	

				I need two? The screen doesn't tell me. You should give me examples of emails, passwords, pins, etc.”	the background is white).” “Give more information and tips to the user”	
1	H1; H6; H3; H9	4; 3	Interaction; Feedback; Visual hierarchy	“It is not noticeable that it is necessary to put a pin code to start.” “Should I register again?” “It is not clear that the four dots are for putting the PIN.“	“Put label like: “Insert PIN code to enter”, if this entry is not automatic” “It should have something like “Insert you pin to enter” More information about login, maybe modifying the component.	
2	H3; H4; H7; H9; H5	3; 2; 4	Interaction; Visual consistency; Labelling;	“I was confused here. “Take me” seems to be an input field” “When I click in the “house” icon I expect to go directly to my address and not to a screen with my home address and work address, it makes me double click.” “There are two identical components that do the same task, it is confusing for the user to distinguish them. Also, icons without text can be problematic.”	“The favorites should have a different look from the search bar, to make it easier to understand the shortcuts” When I click on the “house” icon I should land on the “choose a bus” screen. I think, for some users, it could be important to have labels alongside the icons (just a suggestion). Only one component is needed, two components for nearly identical	

					tasks are confusing.	
6	H3 H1; H2; H5; H6	3; 4	Visual hierarchy; Interaction	“The larger button has the same visual consistency as the Go button. It will prompt the user to click on the “Schedule” button.” “I couldn´t choose a Bus so It was confused that I had to schedule before choosing a bus” “The “Go” CTA is too hidden. The list is too small”	“Create a different look for the “Schedule” button and place it a little smaller and away from the main action.” “Visual hierarchy for the actions. Should I choose the bus first? Then schedule? And Go? What is the order?” “The main CTA should be “Go”, reschedule should me an secondary action/comple mentary action. The space could me more efficiently used.”	
6	H1; H2; H6	4; 3	Visual hierarchy Feedback	“It was hard to find the “Go” button after scheduling the bus. I automatically tapped on “Reschedule” thinking that it was the next action” “It was hard for me to find the program button”	“Visual hierarchy for the main action” “Make the path more linear”	

3	H1; H4; H6; H7; H9	2;3	Feedback; Visual consistency; Interaction; Visual Hierarchy	“Asks to choose a name when we haven't selected an option yet. It is not noticeable that when selecting an option, it is chosen because the button does not give feedback / does not change.” “It´s not clear that I have to choose a name to continue because the “Choose name” field seems already done ✅” “When it asks me to choose a name of the favorite there’s a “check” always present even though I did not write anything.” “The button to choose a name for the "Favorite" should not be the same to complete the task””	“Don't ask for everything at once. Show screen by screen: First select a location and then ask to choose a name.” “If “choose a name” is a required field it should be clear that I have to write something there” “The CTA should hava a label and it should be only enabled when the user inputs any name. It should also be located below the text field.” “Add a conclusion button”	
3	H1; H5; H6	2	Feedback	“The action is conclued here? How can I know if it was added to my favorites or not?”	“It should have a feedback message or it should go to the favorites section after adding it.“	

3	H1; H4; H6; H5; H9	2; 3	Feedback; Visual consistency; Visual hierarchy; Interaction	“The green button seems to be the selected tab info not the enable button” “It´s noticeable which option is selected! “The icons of “Home”, “Work” and Favorites” all seem to be at the same level and grouped together in the previous screen, in this they are divided by tabs.”	“You can use other elements with the colors to make it clear what is the selected tab (line, icon or title on the section) “ “Put the selected one in green” “Is it necessary to divide by tabs? Maybe divide it in another way, or organize the information in another way.”	
5	H7; H9; H5	3; 2; 4	Interaction/ Feedback	“Asks to go back to other menus. It could have a shortcut or automatically redirect me to the menu in question (and then put a new card).” “How can I close this?” “The screen blocked and didn’t advance, so I couldn’t complete the task”	“Shortcut (eg a phrase with a link to the site) or redirect logo to payment sites.” “It should have a close button or a button to send the user to the payments section to try it again” “Review the prototype”	

5	H1; H2	2	Terminology/ Labeling/ Interaction	“I guess we don´t change a card. We eliminate one and add a new one” “1st – After click “recharge” I see an error message, the only help I got was from text, no action to help me. 2nd -> Two different actions on the top of the screen with no clear difference. 3rd -> It seems to be too many clicks to make a recharge.” ““Change” is not very well understood. Uninformative. “The screen after clicking “Change” is the edit screen, which can be a little strange.”	“Recharged pass feedback: it should not be a time-based transition. It should be a new screen” “1st – When I click on “recharge” I should be able to have an option to change the payment information directly on the error message screen.2nd -> When I’m writing the new cards info I can see to actions on the top of the screen “go back” and “close” what’s the difference between one and another? 3rd -> If I can change the card info after the error message the task should proceed smoothly without the for me to click again on “recharge”” “Maybe use “Edit card” or “Edit” or “edit card details”	

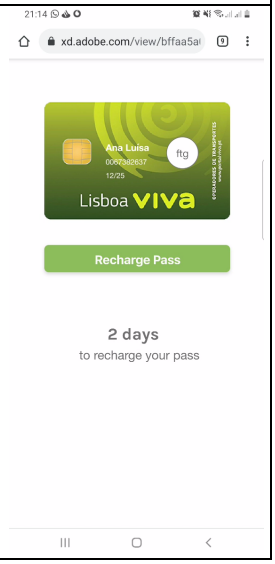
5	H1; H2	2	Feedback	“After the pass was recharged, it still has 2 days to expire.”	“It should have the date that it was recharged. It could be nice to have a historic status list”	

Tabela 4 - Table of the results of the heuristic evaluation for the bus shelter platform

Task	Violated Heuristic	Severity Criteria	Problem category	Problem Found	Suggested Improvements	Screenshot
1	H9	4	Interaction	“There are no labels, you don't know what the interaction is. Is the connection NFC? What if the user does not have NFC turned on?”	“Add information, try to prevent mistakes.”	
1	H1	1	Feedback	“It is not clear what this click step is for until the circle turns green. Is it a login?”	“Add a more explicit title.”	

1	H1	2	Interaction	"The user has to select Olivais several times, not the task status feedback"	"Add steps to the task"	
1	H1; H8; H10	3	Visual hierarchy; Interaction; Feedback	1st in the process there's no clear help to where am I supposed to touch to keep going forward. 2nd When I need to choose the seat, It took me a while to understand the colors and what they meant 3rd It wasn't clear that I should click on the bus stop I wanted, there was no clear difference between that and the main CTA	1st in the process the main arrow "forward" should be highlighted. 2nd Use greys to show the "unable" seats. 3rd Create visual hierarchy between the buttons.	

In the smartphone app the experts found problems in 11 interfaces, in which 9 of 10 heuristic were violated: H1 "Visibility of system status"; H2 "Match between system and the real world"; H3 "User control and freedom"; H4 "Consistency and standards"; H5 "Error prevention";

H6 “Recognition rather than recall”; H7 “Flexibility and efficiency of use”; H9 “Help users recognize, diagnose, and recover from errors”; H10 “Help and documentation”. The most violated heuristic was the H1 “Visibility of system status”, as it is possible to see in the graphic above (Figure 67) and H6 follows H1 with no great difference.

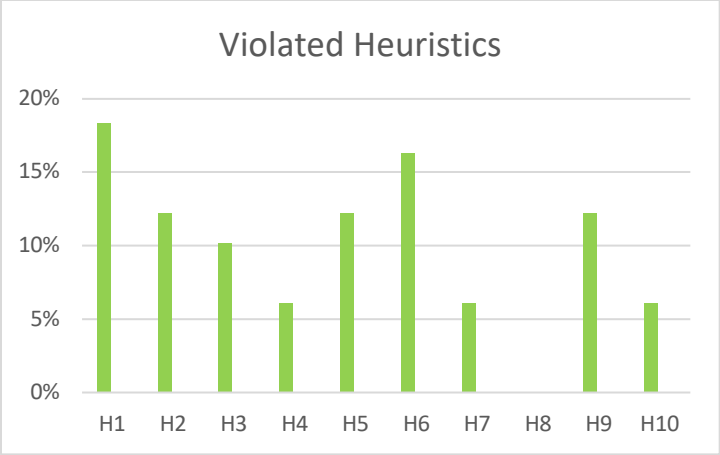


Figure 67 - Violated heuristic in the smartphone app

In the bus shelter platform, the experts found problems in 5 interfaces, in which 4 of 10 heuristic were violated: H1 “Visibility of system status”; H8 “Aesthetic and minimalist design”; H9 “Help users recognize, diagnose, and recover from errors”; H10 “Help and documentation”. The most violated heuristic was the H1 “Visibility of system status”, as it is possible to see in the graphic above (Figure 68).

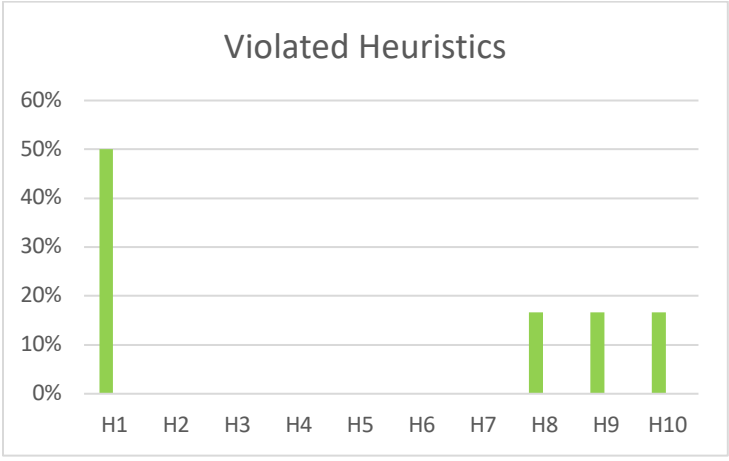


Figure 68 - Violated heuristics in the bus shelter platform

It was asked also asked to the experts that they categorize the problems that they found into 1 = Cosmetic problem only: need not be fixed unless extra time is available on project, 2 = Minor

usability problem: fixing this should be given low priority, 3 = Major usability problem: important to fix, so should be given high priority and 4 = Usability catastrophe: imperative to fix this before product can be released (Nielsen, 1994). In the smartphone app more than 40% of the problems were considered "Minor usability problem: fixing this should be given low priority" as it is shown on the graphic above (Figure 69).

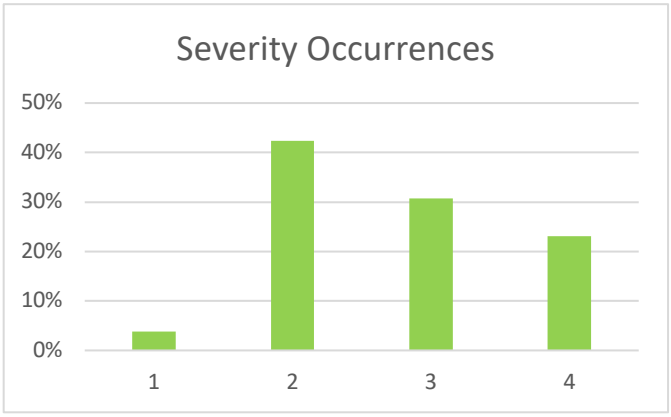


Figure 69 - Severity Occurrences for the smartphone app

On the bus shelter platform there was 4 evaluations, and each evaluation got a different categorization as it is shown on the graphic above (Figure 70).

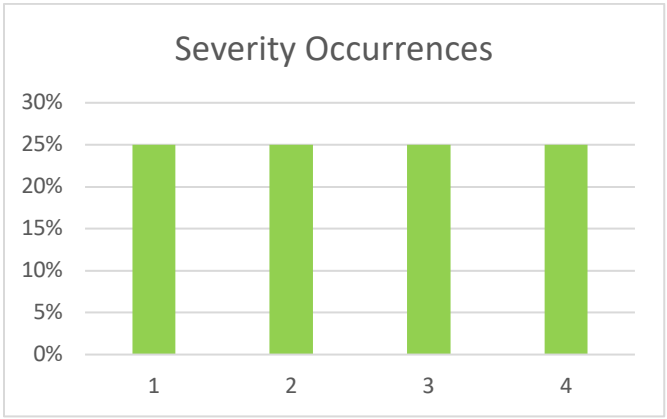


Figure 70 - Severity occurrences for the bus shelter platform

4.6.2.5. Conclusion

The problems found in the smartphone app in the first task were more about information. The experts though that some of the introduction texts should be reviewed and some buttons should be highlighted like the "skip" button. Other problems found were about feedback and prototyping. In the register page the prototype should give feedback to the users when the passwords are a match and the PIN screen entering interface should give some instructions like "insert PIN". The prototype problem was in screen of choosing the language due it was required to the experts to choose the Portuguese (Portugal) language and after they chose the prototype continued in English, this only happened because this thesis is in English.

In the second task the main issue was the icons without labelling text were confusing to the experts and the text "take me" was also confusing, because it looked like a place to write.

In the third task most of the problems were due to feedback and visual hierarchy. The save button should only appeared when the user chooses the name for the new favorite and in the main search screen the icon has the same hierarchy and it's an error.

In the fifth task the main problems were with the prototype and terminology. The screen showing that the payment of the pass had been refused had some problems like the it should change to the next screen with a time changer and due to the prototype platform occurred an error and it didn't change automatically. In the screen to change the payment options most of the users mentioned that it should be "edit" instead of "change". And at last was a terminology problem, in the end of the task the number of days to recharge the pass should be recounting.

In the last task were found two main problems: visual hierarchy and feedback. The "Go" button, according to the experts, should be bigger than the "reschedule" button and the schedule trip button was too hidden.

Overall, there were some critical errors in the prototype[12] that had to be corrected. For the improvements made it is possible to access the them through the following link: https://xd.adobe.com/view/01b328fd-2975-4afb-ace4-2cea8ee94b4c-54e0/ .

In the bus shelter platform, the problems were most of them incorrect information like adding some title or changing titles to be more explicit. The were some interaction errors as well in the interactive prototype due to the used platform. The improvements made to this prototype

[12] Presented in the Appendix L.

can be visualized in the following link: https://xd.adobe.com/view/e7ae647c-b1f3-4160-8b0b-b002ec7ac3e9-b2fd/ .

5. Conclusion and future work

The discussion of the theme of Mobility and its interconnection with areas as relevant as Air Quality, Climate Change, Health and Innovation, will make possible to raise awareness and create the necessary synergies for the pursuit of sustainable mobility, capable of better meeting the mobility needs of people and goods, but in a more environmentally friendly way (Tokoro, 2016).

The mobility and transport sector are an essential sector for human activity, being responsible for the mobility of people and goods. Despite the technological innovation in this field, the transport of people and goods continues to exert great pressures that result in a negative impact on the environment, which is why they are now part of the agenda of national and local authorities around the world (Tokoro, 2016).

This sector is responsible for a large part of the emissions of pollutants, such as nitrogen dioxide and inhalable particles, which contaminate the air we breathe, as well as greenhouse gases that are related to climate changes, and are also in the origin of noise that particularly affects urban areas (Tokoro, 2016).

Due to these problems the main objective of this research is to design and evaluate interfaces for smart bus and bus shelter to encourage citizens to use public transport as a way to combat the sustainability problems of cities. For this purpose, was created an ecosystem that interconnects the user to the bus and bus shelter through two different interfaces, one for the bus shelter and one for the smartphone. To achieve the creation of these two interfaces were taken into account the User Centered Design (UCD) methodology. This methodology divided this work into four steps:

- First stage was the background research;
- Second stage was the product research;
- Third stage was the user research;
- The fourth and final stage was the development and evaluation.

The first step had into account the literature review on smart cities, smart buses, smart kiosks, bus shelters and how was possible for UX Design to help all of these subjects to evolve from today's reality to a future and smarter reality.

The second stage had under consideration the market analysis. In this step was analyzed all of the similar solutions that were already in the market. The apps founded were divided into: maps apps and apps for assisting people to use the public transportation. Some of the first type of apps were the Google maps and Waze. Some of the second kind of apps were Carris and LisboaViagem.

Acknowledging the problems mentioned before, it was fundamental to understand which were the major problems that users associated with buses. So, a questionnaire that inquired 326 people with ages between 15 and 65 years old was made. With the results of this questionnaire, it was possible to understand the major problems in buses like lack of seated seats, the bus is always late or is overcrowded and other minor problems. These identified problems were crucial to build the idea of the MYbus ecosystem.

The step after the questionnaire was picking up the results and identify the target for this ecosystem and frame up the personas and their user journey. In this case, was born four personas that would use the solution proposed in this dissertation5 and one anti-persona that would use this solution.

After the target was well defined it was time to understand the features that were important to be on this ecosystem. This step had into account the research done previously and the market analysis. With all this information was built a navigation plan to demonstrate the planning of both of the interfaces.

The stage four was divided in four steps. The first step was the card sorting test, the second were the wireframes, the third the moderated user testing and the last was the unmoderated heuristic analysis. The card sorting test was made remotely due to the Covid-19 pandemic that didn't allow the gathering of people to test them. This test was built according to the features imprinted on the navigation plan. It showed that were no major hierarchy problems, the minor problems were resolved in the wireframes step. The results of the card sorting defined the creation of the wireframes in the way of displaying the information. This test was done with the Trello tool which wasn't the best tool for the evaluation, however there was not a better free tool.

The moderated user test's objective was to assessment the usability of the wireframes previously built. It gathered twenty-five participants. It was requested to the users to give a classification from 1 to 7 (1 is very difficult and 7 very ease) to classify the difficulty to each task that they performed. The test was formed by six tasks for the smartphone app and 1 task for the bus shelter interface and in the final a questionnaire with only five questions. The results showed

that the lowest rate given to a task was 5,8 (according to the classification given before) giving insights on the tasks that were more difficult to perform.

The layout of both of the platforms were built based on the results of the moderated user testing. The unmoderated heuristic analysis gathered 5 experts on UX and UI design with the objective of assess the principles and guidelines to a good interaction design. Through the Nielsen's ten heuristic thumb rules the participants had to fulfill a table where they were asked the task, the violated heuristic, the severity criteria, problem found, suggested improvements and a screenshot to locate the error or errors found. The errors were corrected and the prototype visible through a link to an interactive prototype presented in the final conclusion of this test.

In terms of future work before implementation of the project there are some tests to do again. It would be important to evaluate, with the Nielsen's heuristics, the changes made in the layout after the last heuristic evaluation. By repeating this test, it is possible to evaluate if there are still some usability problems in the bus shelter platform and in the app for the smartphone.

In terms of implementation of the project in a future work, the first step would be a meeting with the Carris where would be discussed the implementation of a pilot test of the ecosystem Mybus in the Great Lisbon area. During the test would be a collection of data and afterwards these same data would be analyzed and redo the flaws that might be founded in the ecosystem.

The second step would be the implementation of the system in the entire country available only to national citizens and when the program is running without issues all the foreign people can be included to take use of the ecosystem Mybus. The third step and last step would be applying this concept and ecosystem for other means of transportation such as trains for example.

After all of these steps to improve public transportation, namely buses, it is proposed as final step into the future work that the bus becomes driverless, since 90% of the accidents involving collisions result from drivers' errors (Feio, 2019).

In conclusion this thesis contributes to improving the daily usage of the public transportation throughout a user-friendly ecosystem that created two different interfaces.

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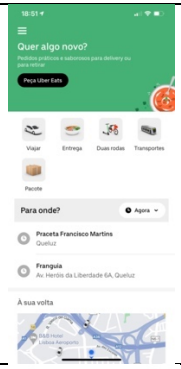
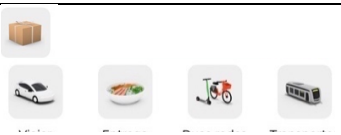
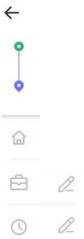
Appendix

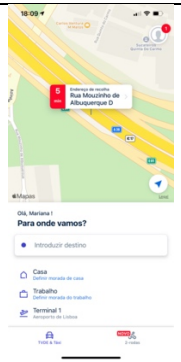
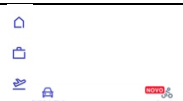
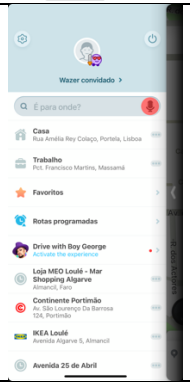
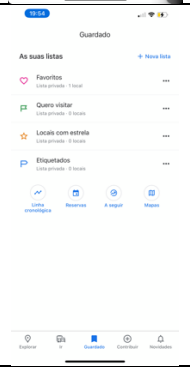
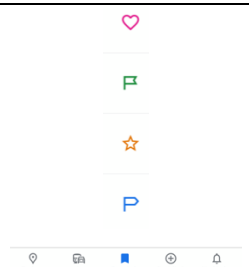
A. Tables of the market analysis

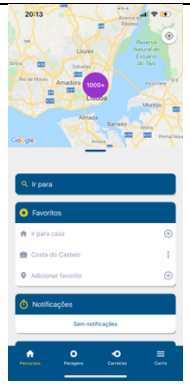
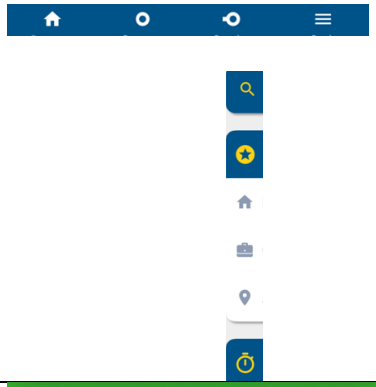
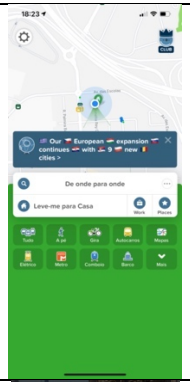
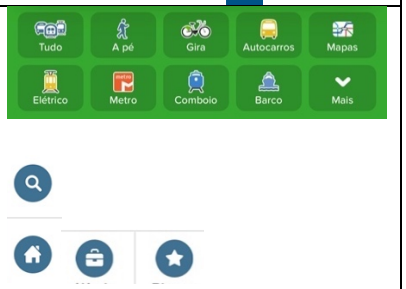
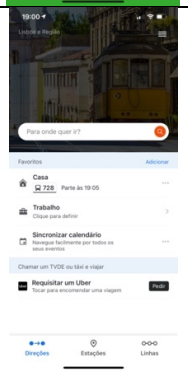
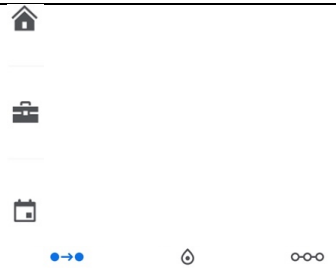
A.1. Interaction

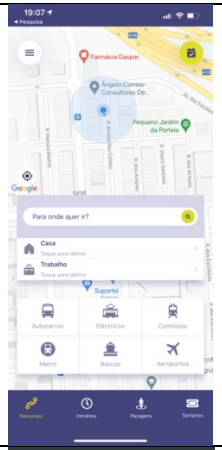
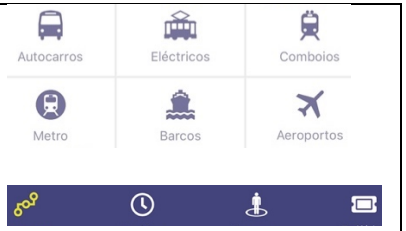
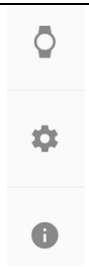
Apps/ Gestures	Tap	Drag	Flick	Swipe	Double tap	Pinch	Touch and hold	Shake	Rotate
Uber	Yes	No	Yes	Yes	Yes	Yes	No	No	No
Bolt	Yes	No	Yes	Yes	Yes	Yes	No	No	No
FreeNow	Yes	No	Yes	Yes	Yes	Yes	No	No	No
Waze	Yes	No	Yes	Yes	Yes	Yes	Yes	No	Yes
Google Maps	Yes	No	Yes	Yes	Yes	Yes	No	No	Yes
Carris	Yes	No	Yes	Yes	Yes	Yes	No	No	No
Citymaper	Yes	No	Yes	Yes	Yes	Yes	No	No	No
Moovit	Yes	No	Yes	Yes	Yes	Yes	No	No	No
Lisboa Viagem	Yes	No	Yes	No	Yes	Yes	No	No	Yes
Suprimidos.pt	Yes	No	Yes	No	No	No	No	No	Yes

A.2. Design characteristics

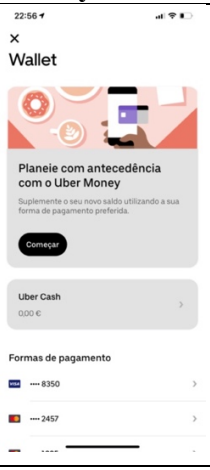
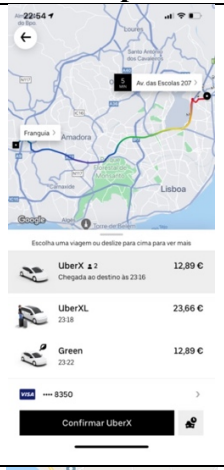
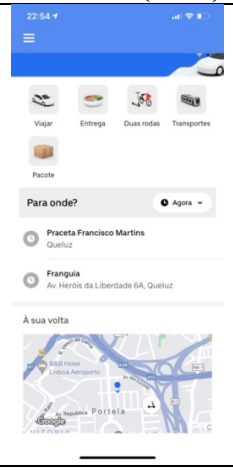
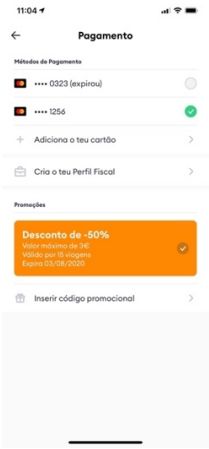
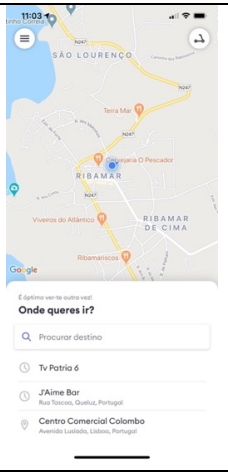
	Primary Color	Secondary Color	Screenshot	Typography titles	Typography text	Icons
Uber	Black	Blue		Quer algo novo? As suas viagens	Franguia Av. Heróis da Liberdade 6A, Queluz 04/12/20, 23:12 Peugeot 5008	
Bolt	Black	Green		Introduzir Destino	Adicionar casa Adicionar local de trabalho Tv Patria 6 J'Aime Bar Centro Comercial Colombo Estação do Oriente	

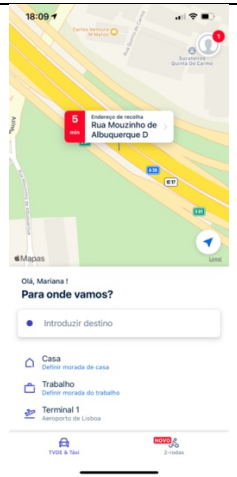
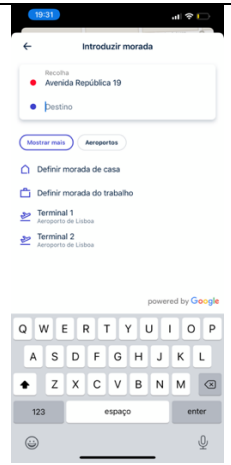
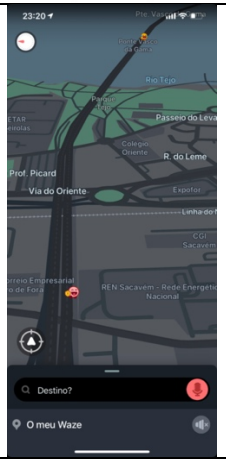
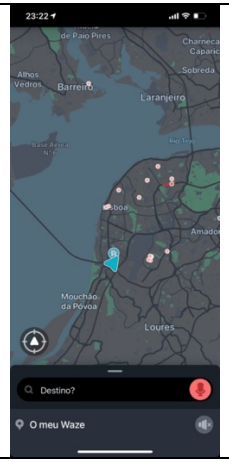
FreeNow	Red	Blue		Para onde vamos?		
Waze	Blue	Grey		Definições	Postos de combustível Velocímetro Leitor de música	
Google Maps	Blue	Green/Yellow		Guardado As suas listas	Favoritos Lista privada · 1 local Quero visitar Lista privada · 0 locais Locais com estrela Lista privada · 0 locais Etiquetados Lista privada · 0 locais	

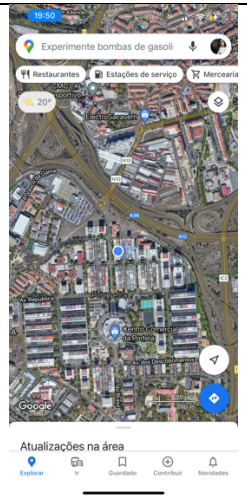
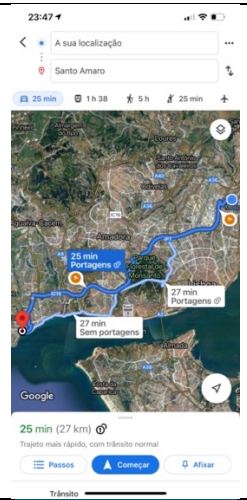
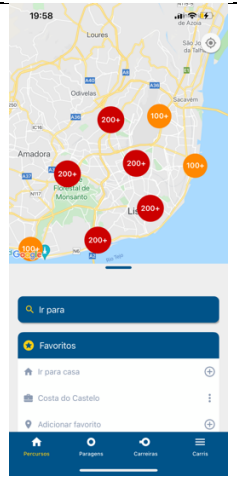
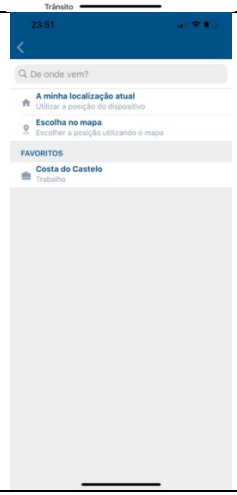
Carris	Blue	Yellow		Favoritos Notificações	Ir para casa Costa do Castelo Adicionar favorito	
Citymaper	Green	Blue		Configurações do app	**TURBO** Ranked by speed, refreshed every minute **SIMPLE** Fewest transfers **PRICE** Cheaper routes and fare comparison **MIXED** Public & private transport	
Moovit	Blue	Orange		Centro de notificações	Não tem notificações novas. Para onde quer ir?	

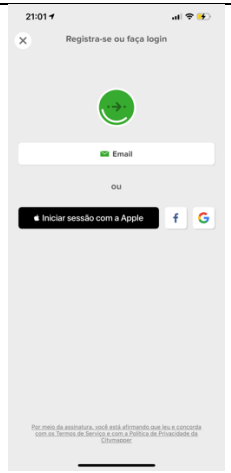
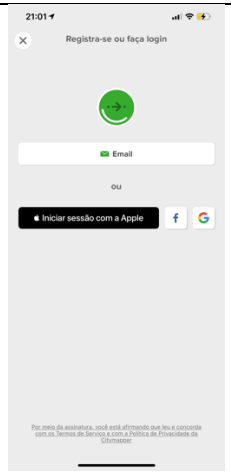
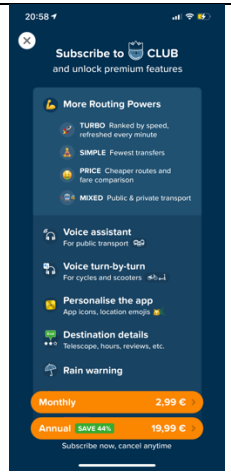
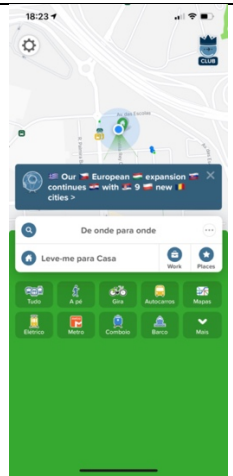
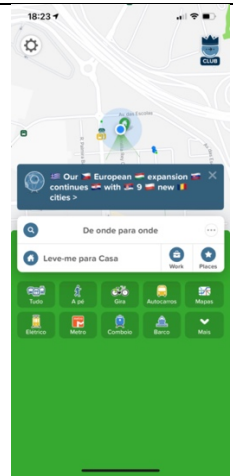
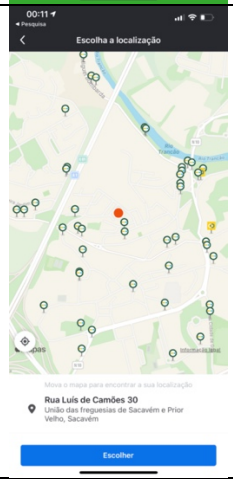
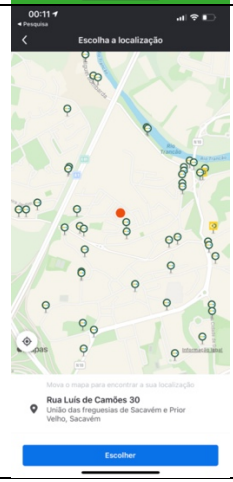
Lisboa Viagem	Blue	Yellow		FAVORITOS	Para onde quer ir?	
Suprimidos.pt	Grey	Green		Notificações		

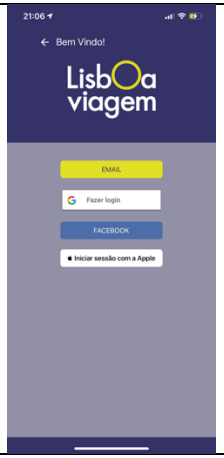
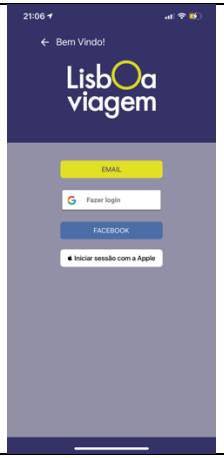
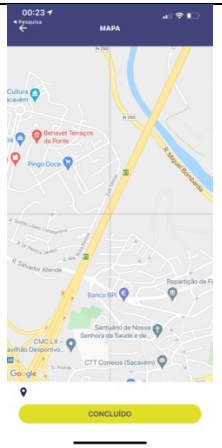
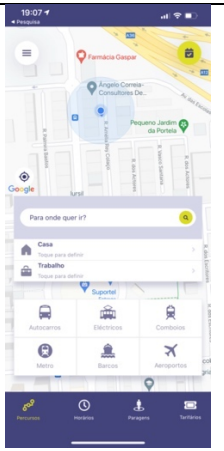
A.3. Contents

	Register	Log in	Payment	Maps	Location (GPS)
Uber					
Bolt					

FreeNow					
Waze			**No**		

Google Maps			**No**		
Carris	**No**	**No**	**No**		

Citymaper					
Moovit	**No**	**No**	**No**		

Lisboa Viagem			**No**		
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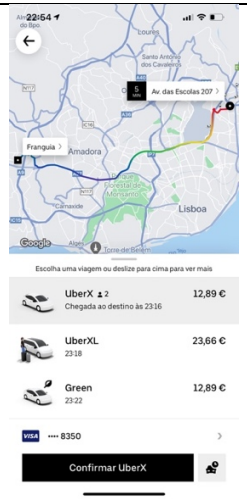
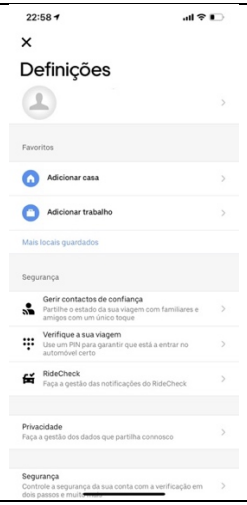
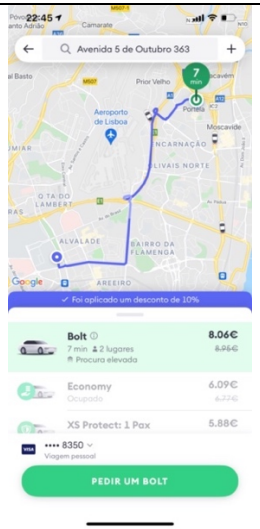
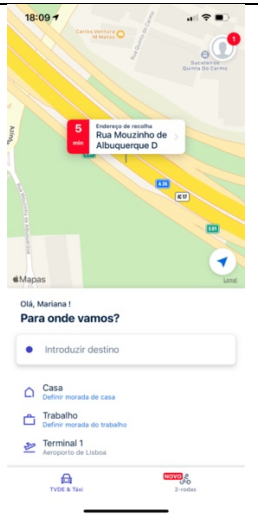
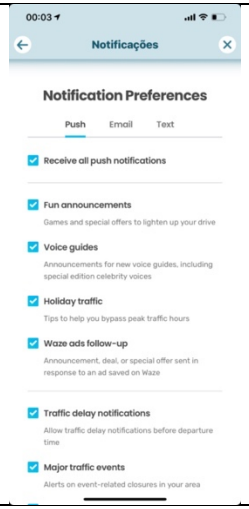
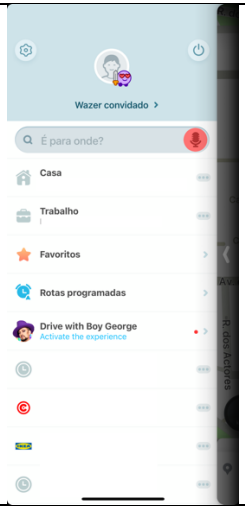
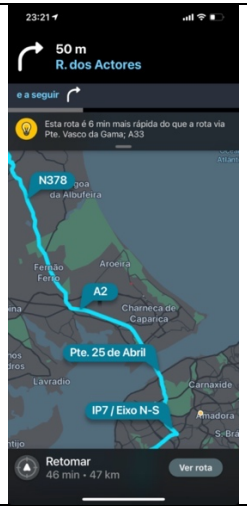
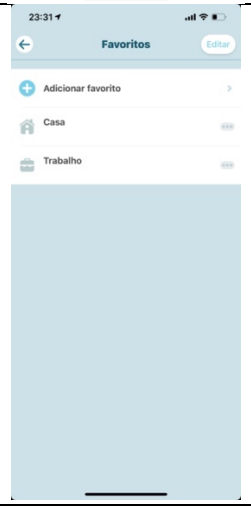
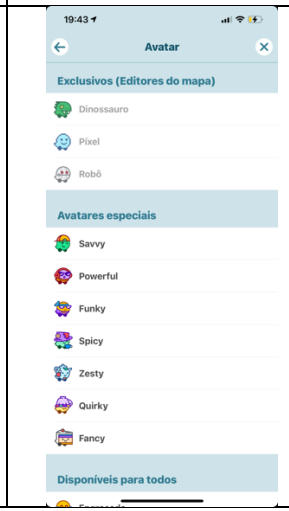
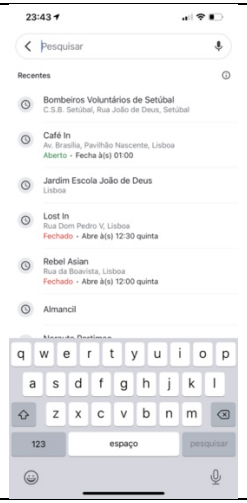
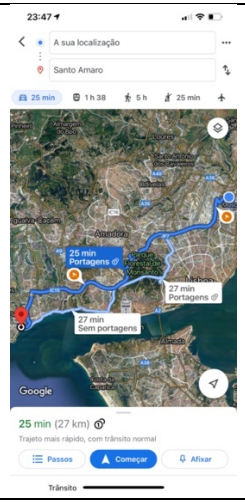
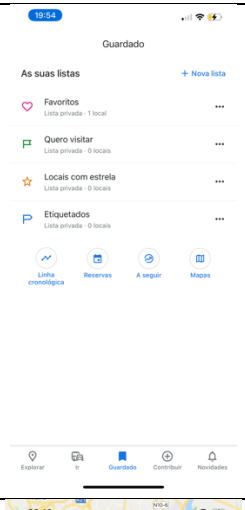
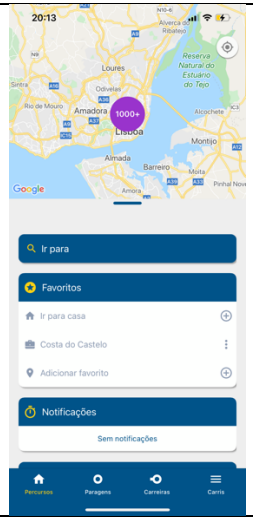
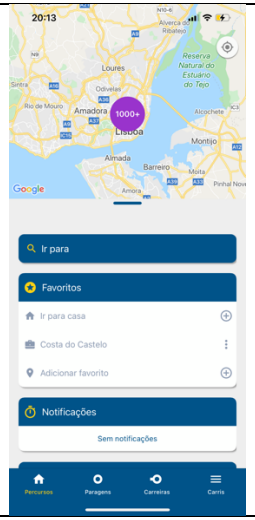
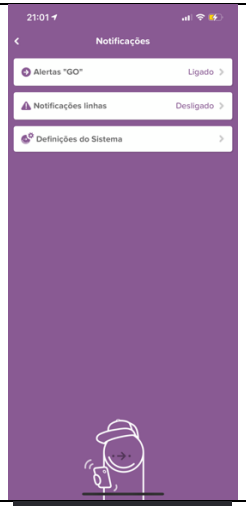
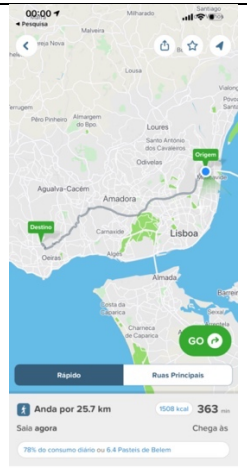
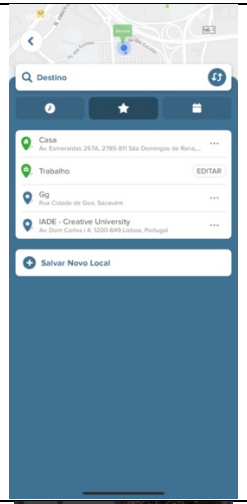
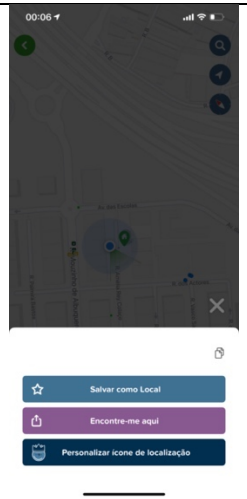
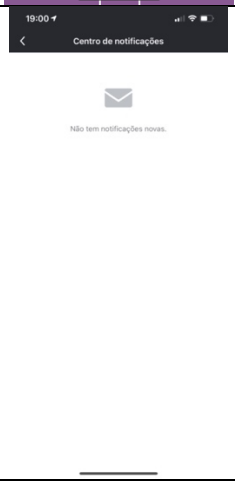
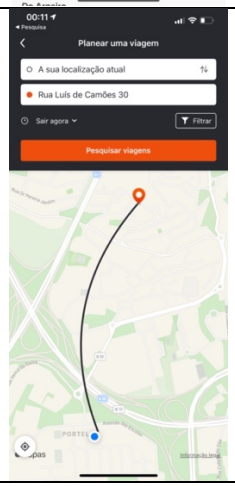
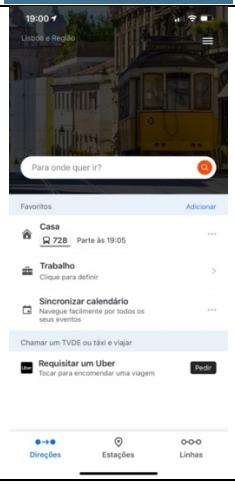
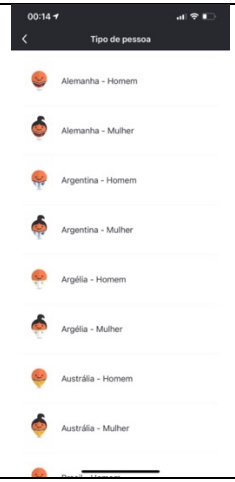
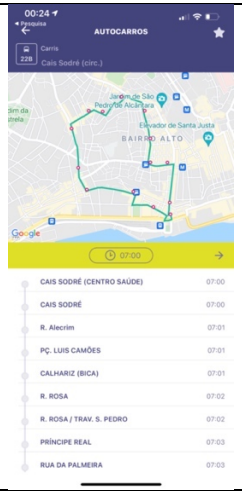
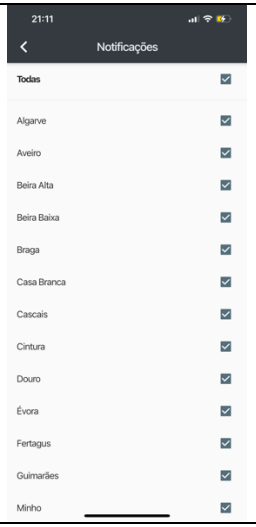
Uber		**No**			**No**
Bolt		**No**		**No**	**No**

FreeNow		**No**			**No**
Waze						

Google Maps					**No**
Carris		**No**	**No**		**No**

Citymaper		**No**			
Moovit		**No**			

Lisboa Viagem	**No**	**No**			**No**
Suprimidos.pt		**No**	**No**	**No**	**No**

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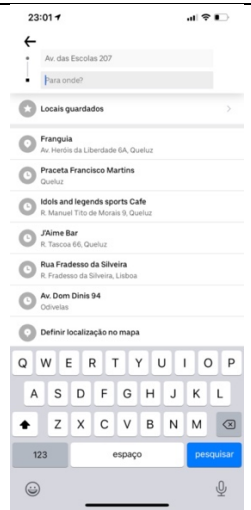
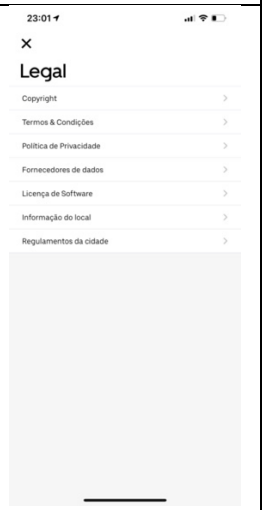
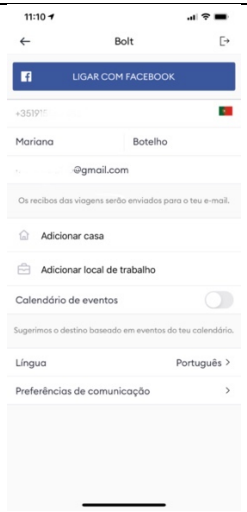
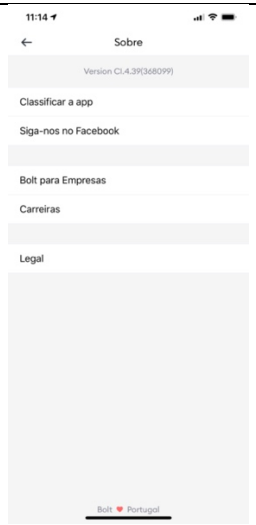
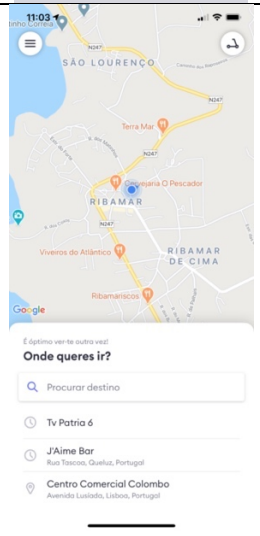
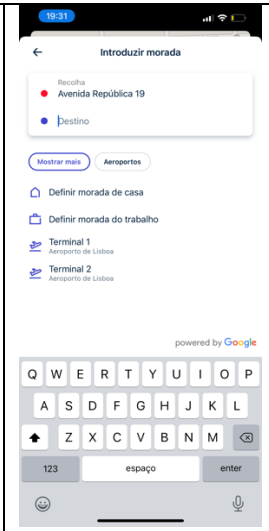
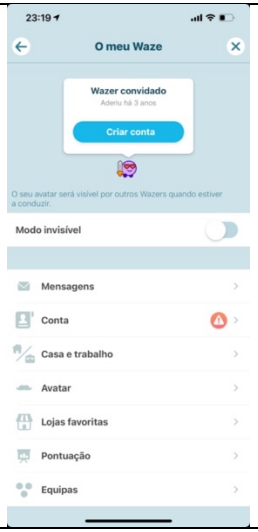
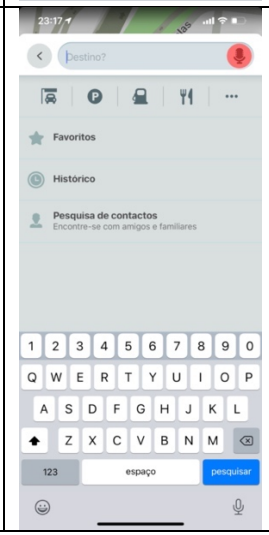
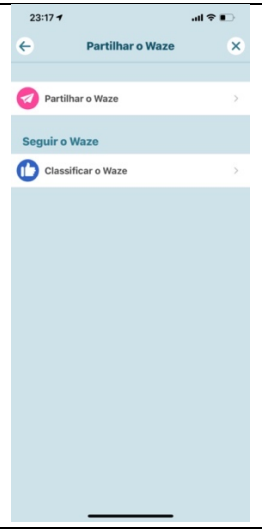
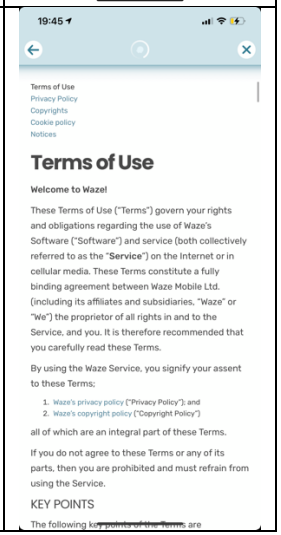
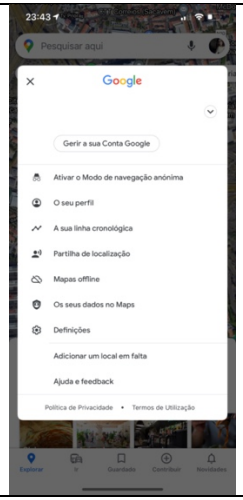
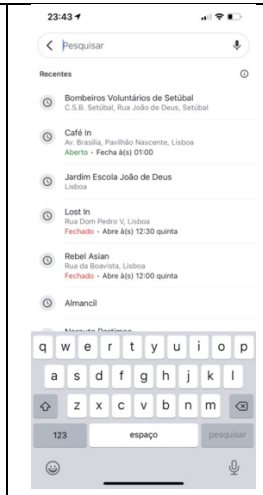
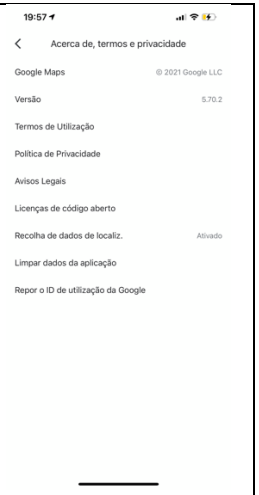
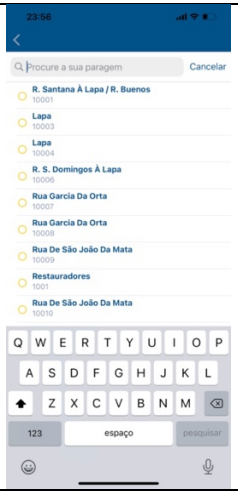
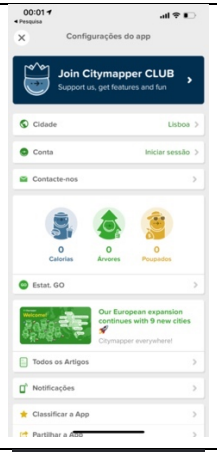
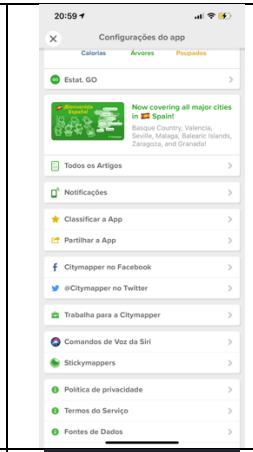
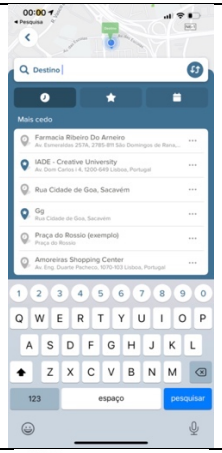
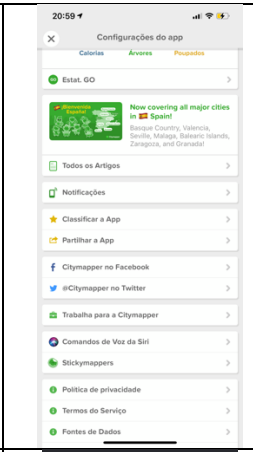
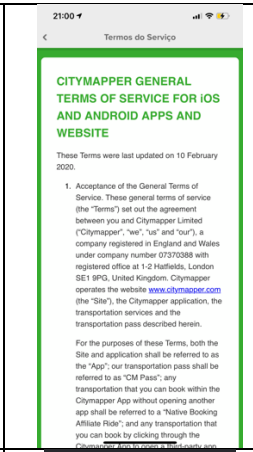
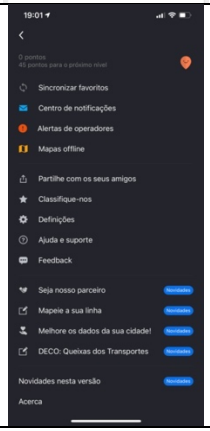
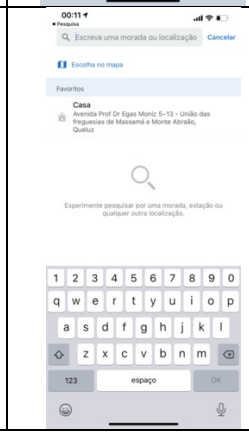
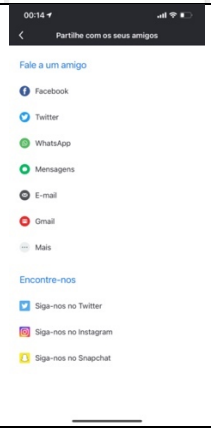
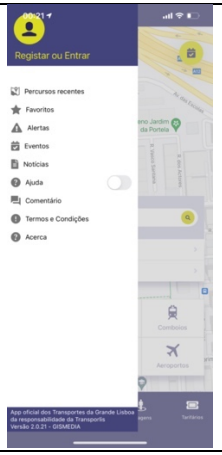
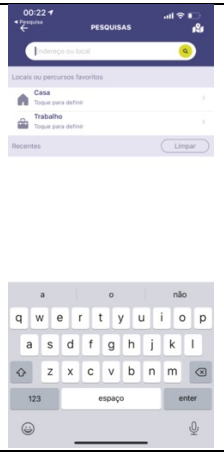
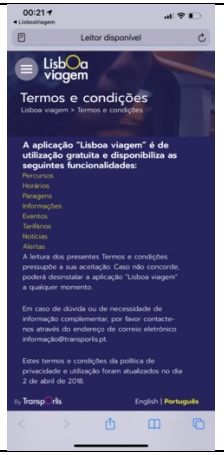
Uber	**No**		**No**		**No**	
Bolt	**No**					

FreeNow	**No**		**No**			
Waze	**No**					

Google Maps	**No**		**No**		**No**	
Carris	**No**	**No**	**No**		**No**	**No**

Citymaper	**No**					
Moovit	**No**					

Lisboa Viagem	**No**		**No**		**No**	
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B. Questionnaire about mobility

O presente estudo tem como objetivo compreender os problemas associados aos transportes públicos, na grande Lisboa, e quais são as possíveis maneiras de melhorar os mesmos. A investigação encontra-se inserida na tese de mestrado de Design de Interação da faculdade IADE.

Para colaborar basta responder a um questionário com a duração aproximada de cinco minutos. A sua participação é voluntária e, por isso, tem o direito de desistir a qualquer momento, se assim o entender. Todos as respostas dadas pelos participantes serão totalmente confidenciais.

1.Idade:

_____

2.Sexo

☐ Masculino

☐ Feminino

☐ Outro

3. Concelho

_____

4. Cidade

_____

5.Nível educacional:

☐ Secundário;

☐ Licenciatura;

☐ Mestrado;

☐ Doutoramento;

6.Profissão:

7.Se possui carro, utiliza carro como meio de transporte para: transição

☐ Trabalho/escola

☐ Lazer

☐ Ao fim-de-semana

☐ Outros

8. Quantas vezes por semana utiliza o seu carro como meio de transporte?

☐ Nunca segue para a pergunta 9

☐ Raramente segue para a pergunta 9

☐ Ocasionalmente segue para a pergunta 9

☐ Frequentemente segue para a pergunta 9

☐ Sempre acaba aqui o questionário

9. Que percursos costuma realizar no seu dia-a-dia?

- Casa-trabalho;
- Escola-casa;
- Casa-trabalho-lazer;
- Escola- lazer- casa;
- Outros;

10.Utiliza transportes públicos?

☐ Nunca

☐ Raramente

☐ Ocasionalmente

☐ Frequentemente

☐ Sempre

11.Qual(ais) o(s) meio(s) de transporte público que utiliza mais frequentemente?

☐ Metro

☐ Autocarro

☐ Comboio

☐ Barco

☐ Metro-comboio

☐ Metro-barco

☐ Metro-autocarro

☐ Autocarro – comboio

☐ Autocarro – barco

☐ Comboio – barco

☐ Outros

12. Escolha um ou mais problemas que considera existir na utilização dos autocarros: envolvimento

☐ Dificuldade em ver horários, Passa para a questão 14

☐ Atrasos frequentes; Passa para a questão 14

☐ Autocarros com ocupação excessiva; Passa para a questão 14

☐ Paragens de autocarro desconfortáveis; Passa para a questão 14

☐ Falta de lugares sentados; Passa para a questão 14

☐ Outros. Passa para a questão 13

13. Qual/Quais são esses problemas?

_____

14. Por norma, quando utiliza um autocarro, consegue usufruir de um lugar sentado?

☐ Nunca Passa para a questão 15

☐ Raramente Passa para a questão 15

☐ Ocasionalmente Passa para a questão 16

☐ Frequentemente Passa para a questão 16

☐ Sempre Passa para a questão 16

15. O facto de raramente ou nunca conseguir usufruir de um lugar sentado influencia-o a não utilizar os transportes públicos, nomeadamente o autocarro?

☐ Nunca

☐ Raramente

☐ Ocasionalmente

☐ Frequentemente

☐ Sempre

16. A que horas julga que deveria haver maior frequência de autocarros por dia?

☐ 8h-10h Passa para a questão 18

☐ 17h-19h Passa para a questão 18

☐ Outros Passa para a questão 17

17. Qual/ Quais são esses horários que deveria haver maior frequência?

_____

18. Os autocarros que costuma usufruir costumam ser pontuais de acordo com os horários pré-estabelecidos?

☐ Nunca Passa para a questão 19

☐ Raramente Passa para a questão 19

☐ Ocasionalmente Passa para a questão 20

☐ Frequentemente Passa para a questão 20

☐ Sempre Passa para a questão 20

19. O facto dos autocarros nunca ou raramente serem pontuais é um fator determinante a não os utilizar como meio de transporte?

☐ Nunca

☐ Raramente

☐ Ocasionalmente

☐ Frequentemente

☐ Sempre

20. Quando se encontra à espera do autocarro, costuma mandar uma mensagem, para o número anunciado na paragem do autocarro, para saber quanto tempo demora a chegar o mesmo?

☐ Nunca

☐ Raramente

☐ Ocasionalmente

☐ Frequentemente

☐ Sempre

21.Caso já tenha utilizado este serviço de enviar uma mensagem para saber o tempo de espera do autocarro, ficou satisfeito com o serviço?

	1	2	3	4	5	6	7	8	9	10	
Nada satisfeito	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	Completamente satisfeito

22.Que aplicações conhece que facilitem a utilização dos transportes públicos?

transição

☐ Moovit Passa para a questão 23

☐ Google Maps Passa para a questão 23

☐ Anda Passa para a questão 23

☐ Citymaper Passa para a questão 23

☐ Suprimidos.pt Passa para a questão 23

☐ Lisboa Viagem Passa para a questão 23

☐ Move-me Passa para a questão 23

☐ Nenhuma Passa para a questão 24

☐ Outras_____ Passa para a questão 23

23.Qual a aplicação que utiliza mais frequentemente?

24.Porquê? Acaba o questionário

25.Com que frequência utiliza a aplicação?

☐ Nunca

☐ Raramente

☐ Ocasionalmente

☐ Frequentemente

☐ Sempre

26.Utiliza a aplicação com que propósito?

☐ Para ver o horário; Passa para a questão 28

☐ Para ver os percursos dos autocarros; Passa para a questão 28

☐ Para ver qual o percurso dos meios de transporte mais rápidos; Passa para a questão 28

☐ Outros. Passa para a questão 27

27.Qual/Quais são esses propósitos que o leva a utilizar a aplicação?

_____

28.Por favor classifique as características da aplicação consoante a sua importância. Sendo que 1 corresponde a nada satisfeito e 10 completamente satisfeito:

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Utilidade	☐	☐	☐	☐	☐	☐	☐	☐	☐
Facilidade de utilização	☐	☐	☐	☐	☐	☐	☐	☐	☐
Design	☐	☐	☐	☐	☐	☐	☐	☐	☐
Segurança (dados pessoais)	☐	☐	☐	☐	☐	☐	☐	☐	☐
Custo	☐	☐	☐	☐	☐	☐	☐	☐	☐

Obrigada pelo seu tempo.

C. Design of the questionnaire

The questionnaire is divided into three parts, the first one refers to sociodemographic data, the second to public transport and the last part to applications associated with public transportation.

The first part of the questionnaire, referring to the sociodemographic data of the respondents, serves to characterize the population using mostly public transportation. The second part concerned aims to assess what are the real problems that exist in public transportation, namely in buses, and what are the routes that the population uses the most and how many times a week they use buses as a means of transport. The third part focuses on the existing applications that make the use of public transport simpler, what these are and what are their best features.

This questionnaire presents multiple questions, these are screening questions, warm-ups, transitions and development. The screening questions are:

Question number 8. ***Quantas vezes por semana utiliza o seu carro como meio de transporte?***
This question is important to understand if people who own a car always use it instead of public transportation and even to perceive if it makes sense to the questioned person to continue the questionnaire or end up in this question.

Question number 14. ***Por norma, quando utiliza um autocarro, consegue usufruir de um lugar sentado?***
This question is used if the respondents answer that they never or rarely get a seat on the bus move on to another question related to their satisfaction, if they answer occasionally, frequently and always move on to another question.

Question number 16. ***A que horas julga que deveria haver maior frequência de autocarros por dia?***
This question is used if the respondents answer other schedules other than those that exist in the options to move to another question that answers what / what is / are these / these times / schedules.

Question number 18. ***Os autocarros que costuma usufruir tendem a ser pontuais de acordo com os horários pré-estabelecidos?***

This question is used if the respondents answer that buses never or rarely are punctual and go on to another question related to their satisfaction, if they answer occasionally, frequently and always go on to yet another question.

Question number 26. ***Utiliza a aplicação com que propósito?***
This question is used if the respondents answer other purposes other than those that exist in the options to move on to another question that have to answer what are these purposes.

The transition questions are:

Question number 7. ***Se possui carro, utiliza carro como meio de transporte para:***
This question makes the transition from the theme of sociodemographic data to the theme of existing applications to facilitate the use of public transportation.

Question number 22. ***Que aplicações conhece que facilitem a utilização dos transportes públicos?***
This question makes the transition from the theme of public transport to the theme of public transportation.

The warm-up question is:

Question number 12. ***Escolha um ou mais problemas que considera existir na utilização dos autocarros:***
This question serves to involve respondents in the theme of problems in public transport, encouraging them to contribute with their opinion

The development questions are:

Question number 1. ***Idade:***
This question aims to assess the age of the population that most uses public transportation.

Question number 2. ***Sexo:***
This question aims to assess the gender of the population that most uses public transportation.

Question number 3. ***Concelho:***
This question aims to assess the municipalities of the population that most uses public transportation.

Question number 4. ***Cidade:***

This question aims to assess the cities of the population that most use public transportation.

Question number 5. ***Nível educacional:***
This question aims to assess the educational level of the population that most uses public transportation.

Question number 6. ***Profissão***
This question aims to understand whether the profession has any influence on the use of public transport.

Question number 9. ***Que percursos costuma realizar no seu dia-a-dia?***
This question aims to assess what are the routes that the respondents most use in their day-to-day.

Question number 10. ***Utiliza transportes públicos?***
This question aims to understand how many people uses or not the public transportation.

Question number 11. ***Qual(ais) o(s) meio(s) de transporte público que utiliza mais frequentemente?***
This question aims to assess the preferences of the population in terms of public transportation.

Question number 13. ***Qual/quais são esses problemas?***
This question aims to assess what are the problems that users consider to exist in buses.

Question number 15. ***O facto de raramente ou nunca conseguir usufruir de um lugar sentado influencia-o a não utilizar os transportes públicos, nomeadamente o autocarro?***
This question aims to assess whether having a seat in public transport, namely in buses is a determining factor for using them or not.

Question number 17. ***Qual/quais são esses horários que deveria haver maior frequência?***
This question aims to assess which are the times in the schedule that should be more buses.

Question number 19. ***O facto dos autocarros nunca ou raramente serem pontuais é um fator determinante a não os utilizar como meio de transporte?***

This question aims to assess whether the punctuality of buses is a determining factor for their use or not.

Question number 20. ***Quando se encontra à espera do autocarro, costuma mandar uma mensagem, para o número anunciado na paragem do autocarro, para saber quanto tempo demora a chegar o mesmo?***
This question aims to assess the usefulness of the system that already exists to know what will be the real time at which the bus will arrive at the stop.

Question number 21. ***Caso já tenha utilizado este serviço de enviar uma mensagem para saber o tempo de espera do autocarro, ficou satisfeito com o serviço?***
This question aims to assess whether people who have already used the mentioned service were satisfied or whether the service needs to be improved.

Question number 23. ***Qual a aplicação que utiliza mais frequentemente?***
This question aims to assess which application, within which the respondent mentioned previously, the one that he or she one uses more.

Question number 24. ***Porquê?***
This question is for respondents to answer the reason why they do not use any type of app and this way the questionnaire ends here, since the remaining questions are related to applications.

Question number 25. ***Com que frequência utiliza a aplicação?***
Esta questão tem como objetivo aferir a frequência com que o utilizador recorre à aplicação para entender o grau de necessidade e de satisfação do mesmo, quanto à aplicação.
This question aims to assess the frequency with which the user utilizes the application, in order to understand the degree of need and satisfaction of the user with the app.

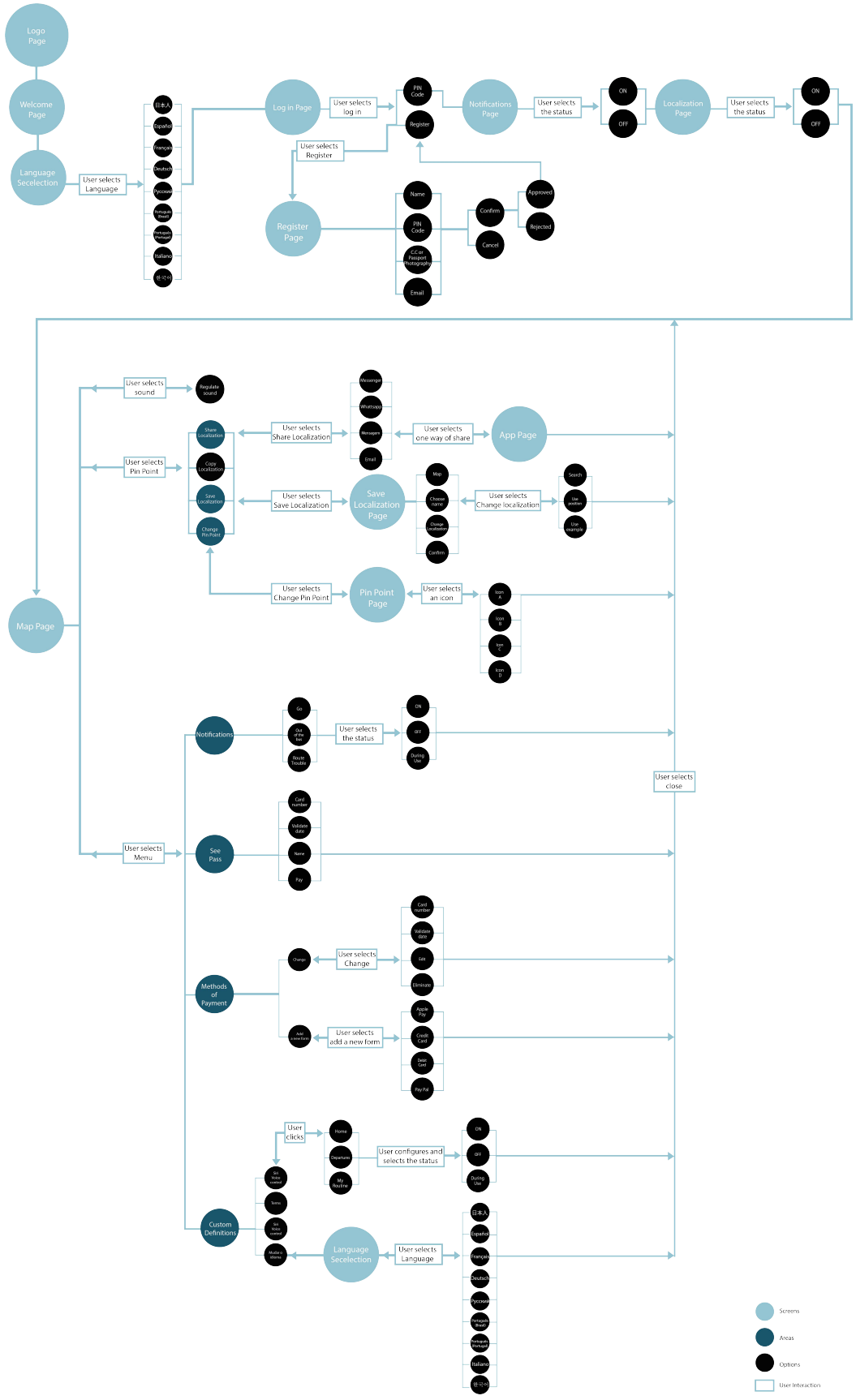
Question number 27. ***Qual/Quais são esses propósitos que o leva a utilizar a aplicação?***

This question aims to assess what are the purposes in an app that leads users to utilize it when they use public transportation, namely buses.

Question number 28. ***Por favor classifique as características das aplicações consoante a sua importância. Sendo que 1 corresponde a muito insatisfeito e 9 muito satisfeito:***
This question aims to assess what are the characteristics that the user considers most important

in an application whose main focus is to make simple to people the use of public transportation, namely buses.

D. Navigation Plan



E. Results of the card sorting test

E.1. Smartphone Results test

	Category 1 - Log In Page	Category 2 - Register Page	Category 3 - Language Selection	Category 4 - Menu	Category 5 - Map Page
Card 1 - Pin Code	90%	10%			
Card 2 - Pin Code Forgotten ?	100%				
Card 3 - Pass	30%	5%		65%	
Card 4 - Register	75%	20%		5%	
Card 5 - Name	25%	75%			
Card 6 - E-mail + Confirmation		100%			
Card 7 - Pin Code + Confirmation		100%			
Card 8 - Photography of CC or Passpor		95%		5%	
Card 9 - Español			100%		
Card 10 - Português			100%		
Card 11 - English			100%		
Card 12 - Français			100%		
Card 13 - Home				40%	60%
Card 14 - Methods of Payment		5%		95%	
Card 15 - Notifications				95%	5%
Card 16 - Custom Definitions	5%	5%		90%	
Card 17 - More			40%	35%	25%
Card 18 - Favorite				30%	70%
Card 19 - Where are you going ?				5%	95%
Card 20 - Recent				10%	90%
Card 21 - Map				35%	65%
Card 22 - Work				10%	90%

E.2. Bus Shelter Results test

	Category 1 - Bus selection	Category 2 - Bus stop selection	Category 3 - Seat map selection	Category 4 - Forms of payment
Card 1 - Bus 712	95%		5%	
Card 2 - Bus 720	95%		5%	
Card 3 - Bus 38	100%			
Card 4 - See Map	20%	80%		
Card 5 - Stop A Picoas		100%		
Card 6 - Stop B Rato		100%		
Card 7 - Stop C Estrela		100%		
Card 8 - Stop D Cova da Mour		100%		
Card 9 - Stop E Calvário		100%		
Card 10 - Seat A1			100%	
Card 11 - Seat B1			100%	
Card 12 - Seat C1			100%	
Card 13 - Seat D1			100%	
Card 14 - Seat E1			100%	
Card 15 - ATM				100%
Card 16 - Visa/MasterCard				100%
Card 17 - PayPal				100%
Card 18 - Pass	5%			95%

F. Moderated Test Presented to the participants

Teste de Usabilidade

Mestrado Design de Interação.
IADE - Universidade Europeia

Introdução

O presente teste, inserido numa tese de mestrado, tem o propósito de avaliar as aplicações para duas distintas plataformas, que ajudam a melhorar os transportes públicos atuais, nomeadamente os autocarros. A partir de algumas tarefas será possível entender se estas são complicadas ou fáceis de executar, desta forma, é importante ter em mente que **não existem respostas certas ou erradas.** Cada participante desempenha um papel fundamental no melhoramento destas duas plataformas, pretendendo-se que no final se torne muito mais simples utilizar os autocarros como meio de transporte. O teste é composto por 7 tarefas curtas, 6 para a aplicação destinada ao telemóvel e 1 para a aplicação para o ecrã da paragem de autocarro. No final da realização do teste pede-se que responda a um pequeno questionário com o propósito de melhorar as duas plataformas. É de mencionar que todas as respostas são anónimas.

O teste está dividido em 3 passos:

1 – Compreender o cenário enquadrante do teste

2 – Completar as tarefas através dos links

3 – Responder a um questionário no final

Cenário

Num futuro próximo não terá que se deslocar ou a quiosques ou ao multibanco para conseguir carregar o seu passe, poderá fazê-lo através do telemóvel, tal como verificar quando é que terá de o carregar. Quando chega à paragem de autocarro conseguirá marcar o seu lugar dentro do autocarro e verificar em tempo real onde se encontra o autocarro que pretende entrar para prosseguir a sua viagem. Tantas inovações que serão possíveis dentro de um futuro próximo e o que lhe é pedido é que imagine todas estas novas funcionalidades quando estiver a realizar as tarefas. É de mencionar novamente que **não existem respostas certas ou erradas.**

Cenários

Para aplicação destinada ao telemóvel são dados 7 cenários para perfazeres 7 tarefas:

Cenário 1: Registo

Esta é a primeira vez que vais interagir com esta aplicação, faz o registo sff

Link: https://xd.adobe.com/view/d22132ff-9bdc-46e3-71e9-0d4aafb0f462-a410/

Cenário 2: Vá para casa

Encontras-te no restaurante, no entanto, já terminaste a tua refeição e queres ir para casa de autocarro, encontra o teu autocarro.

Link: https://xd.adobe.com/view/cc6ad267-6b22-48b7-75c9-cf5bdebac577-ba5b/

Cenário 3: **Adicione aos favoritos**

Vais muitas vezes ao IADE, adiciona o IADE aos seus favoritos.

Link: https://xd.adobe.com/view/542ab562-4490-408c-7113-c046d5793eac-221b/

Cenário 4: **Vê o teu passe**

Não te lembras de quando foi a última vez que carregaste o teu passe, verifica quanto tempo falta para o recarregares.

Link: https://xd.adobe.com/view/a2936719-d517-4f82-594d-18079c4d7f61-d4a2/

Cenário 5: **Recarrega o teu passe**

Tens de carregar o teu passe, por favor recarrega o passe com o cartão da mastercard que já está selecionado.

Link: https://xd.adobe.com/view/810fe0f7-414a-4c97-660d-316ee9eff4f2-f73e/

Cenário 6: **Agenda a tua viagem**

Tens uma reunião às 18h no Vasco da Gama. Agenda a tua viagem, escolhendo o autocarro 755.

Link: https://xd.adobe.com/view/193b1223-95e7-4844-6789-c82a304056bc-6f0a/

Para a aplicação destinada à paragem de autocarro é uma tarefa:

Cenário 1: Compra o bilhete

Vais ter uma consulta no hospital que fica nos Olivais, escolhe os Olivais como paragem e como tens pressa, escolhe o autocarro que chega mais depressa. Como tens o passe pago, aproveita e paga a tua viagem com o passe.

Link: https://xd.adobe.com/view/4a3378cd-7065-4b31-6f82-9c2d23fbf199-3c02/

Questionário

Avalia de 1 a 7 (sendo um muito difícil e 7 muito fácil) o grau de dificuldade que sentiu ao perfazer cada tarefa nas duas diferentes plataformas:

Aplicação de telemóvel

Tarefa 1:_____

Tarefa 2:_____

Tarefa 3:_____

Tarefa 4:_____

Tarefa 5:_____

Tarefa 6:_____

Plataforma da paragem de autocarro

Tarefa 1:_____

Na aplicação para smartphone existe algum ícone, texto ou cor que não façam sentido para ti?

Na plataforma para a paragem de autocarro existe algum ícone, texto ou cor que não façam sentido para ti?

Na aplicação para o smartphone existe uma opção de notificações que têm o propósito de te alertarem sobre horários dos autocarros, as horas que tens de sair de casa para apanhares o autocarro a horas entre outras. Quais é que são as notificações que para ti mais fazem sentido?

Julgas que a cor verde faz sentido estar associada a estas duas plataformas? Tendo em conta que são sobre autocarros?

_____

Julgas que ambas as aplicações (para smartphone ou para a plataforma da paragem de autocarro) necessitam de mais conteúdo? Ou de menos conteúdo?

_____

Obrigada pelo teu tempo!

G. Table of the difficulty of the tasks given per user

	Phone						Bus
User/Task	**1**	**2**	**3**	**4**	**5**	**6**	**1**
1	7	7	7	7	5	6	7
2	6	6	5	7	6	6	6
3	6	6	6	6	7	5	6
4	7	7	7	7	6	7	7
5	6	6	5	7	7	5	6
6	7	7	7	7	7	6	7
7	7	6	7	7	6	7	7
8	7	7	7	7	7	6	7
9	7	6	6	7	7	7	6
10	7	7	7	6	6	7	7
11	6	4	4	7	7	4	7
12	6	5	5	7	5	5	5
13	5	4	4	7	4	5	5
14	6	4	6	7	6	4	5
15	7	5	7	6	7	4	7
16	7	5	7	5	6	5	7
17	6	3	7	7	7	6	3
18	7	6	5	7	7	6	6
19	6	5	4	6	6	4	7
20	7	6	7	7	5	7	7
21	6	6	7	6	7	6	7
22	5	5	6	6	7	7	7
23	6	7	5	7	7	5	7
24	7	7	6	7	7	7	7
25	7	7	5	6	6	7	7

H. Table of the answers of the questionnaire

User/ Question	1	2	3	4	5
1	I didn’t quite understand why I couldn’t pay the pass in the “payment” option, but I had to go to the “pass” option.	No	When it's necessary to recharge the pass.	Yes	I think they are fine because they are simple and intuitive.
2	No	No	The time that I have to leave home to catch the bus.	Yes, because it's a color associated with positivity.	At the outset, I don't think they need more content.
3	No	No	Notification like is missing 5 minutes to catch the bus.	Yes	Neither one nor the other has insufficient content.
4	No	No	Alert to leave the hpuse on time to catch the transportation, alert to recharge the pass.	Yes. Because it's a smooth and tranquilizer color.	No, that's fine like this.
5	Yes, I think the C.C. we have to give authorization to be used	No	Alerts about the schedulesand about leaving the house are the most importants to know how to run my time.	Yes, or green or orange, which are appealing and undead colors.	Book the seats I think there is not so much need, just to check how many seats there are.
6	No	No	The time that I have to leave the h	Yes, I associate it with the pass.	No, I think it's complete.
7	No	No	Schedules, time to leave the house.	Yes, because everything associated with transportation is green.	It's ok, more content would complicate its utilization.
8	No	No	Pass validity.	Yes	It's fine like it is, simple and direct.
9	No	Colors of the bus's seats	Recharge the pass.	Yes	It's fine like it is, more content would be confuse.
10	No	No	Notify me: the X days to the end of pass validity; X buses to the most used destinations.	Yes or yellow	In the app for the smartphone, the value of the payment of the pass can be added; possibility of recording payments made; having a history of trips made; notifications to warn about delays and add the possibility for users to leave feedback on trips made (delays, occupation, driving, among others).

11	I missed labeling in some icons like the selection of the hour.	This is one 100% ok	I would say that are the bus's schedules and alerts to recharge my pass.	It doesn't shock me at all, we have to make sure that they are different greens from the successful messages	It seems to me that the content is on point, the only thing I feel that can be adjusted is the CTA to "move forward" in the registration process and eventually the flow of going home and saving it to favorites, it was unclear where I had to click.
12	Não, but I would like to have more information.	No, but I think that the process is too long.	If the bus is late.	Yes.	The bus stop process should be shorter and more simple.
13	Lack of labeling and clarity in instructions.	I think that are labels missing, don't understand why using the fingerprint if we already have identified with the phone; don't know why we choose a method of payment. Shouldn't we charge or associate the app to 1 card?	Early notification of the arrival of the bus with the time interval chosen by me. EX: notify me 10m before the bus arrives. Delay notification	I do not have a position on the matter. I don't see the connection to be, but I don't see anything against it.	The one on the phone is ok in terms of content, it needs more instructions (labels); the one at the stop, it seems very complicated. I don't see the option of choosing a seat as being practical, nor do I know how you can guarantee that that seat will be mine. I don't understand why I have to identify myself with the phone and fingerprint or why I have to choose a payment method. For the rest it is ok.
14	No	No	What time do I have to leave the house and alerts from x to x time of how much time is left for the bus to arrive	Bearing in mind that one of the objectives of using public transport is precisely to save the environment, yes.	More content I think not, however I feel that the destination choice screens are a bit confusing (the choice of a favorite could be inside a screen by clicking on “Where are we going”, making the screen simpler and more intuitive)
15	No	No	Alerts on schedules and traffic.	Yes	Notion of traffic can be good
16	The Menu Button is poorly identified	Everything is ok	Arrival time at destination (end of trip)	No, people identify buses by their yellow color	No

17	The application seems a little monotonous, I would have liked to see a more vivid green that was less monochromatic, the use of space is also not the best, in my opinion, namely in the selection of destination with too many blank spaces and some icons too small.	Task 1, slide 11 doesn't feel that "only 4 numbers" is correct. Task 4, slide 2 doesn't seem to me that you say pass in english. In the end of task 6 say End task 5. In the choice of bus, scenery 1 that jumps to slide 8 to 25. Next in X minutes doesn't sound good.	New buses created in my recorded places. I would like to know if there are changes in the route or if a new bus has appeared next to me that I am not aware of. I would like to know if the bus capacity exceeds a percentage. If it is already at 95%, I might prefer to take another one that takes a little longer, for example.	Yes, it is already associated with the pass, I wish that had been used a more "cheerful" green.	Less content, mainly to choose the bus, I thought it had too many steps. I did not understand the purpose of slide 11, to say where I want to leave, since the application should know where the nearest exit is and tell me where I should leave. I also don't think that the seat marking makes sense, because I can get on the bus and have someone sitting in my seat who doesn't have the application.
18	No	No	Alert to the bus's schedules.	Yes	I don't know, they seem to have enough content.
19	No	No	Alert notification on the bus's schedules.	Yes	From my point of view the icons of both applications are very intuitive and easy to understand, since there are not many, it makes the application simple to understand
20	No	Colors of the bus's seats in grey scale	The time I have to leave the house to catch the bus on time.	Yes	That's enough
21	No	Colors of the bus's seats in grey scale	The time I have to leave the house to catch the bus on time.	Yes	I think they should have the travel time. I don't think they should have the CC.

22	The Schedule button could be replaced by another symbol or “schedule”	No	Time to leave the house,time till the next bus, if the bus that I scheduled is late or not.	Yes	They may need more content. For example “planned occupation by career” of the kind as it appears on google maps
23	No	No	Alert me when I have to leave the house.	Yes	I think it's fine like it is.
24	The Schedule button could be replaced by another symbol or “schedule”	No	Time to leave the house,time till the next bus, if the bus that I scheduled is late or not.	Yes	It was interesting to know the actual and average delays taking into account the time, and to receive notifications of alternatives in case of any unusual delay.
25	No	No	Notification to recharge the pass.	Yes, it reminds me of public transport.	No, otherwise it becomes more confusing

I. Unmoderated test presented to the participants

Usability test for an Ecosystem named MYbus

Mariana Botelho – IADE - Creative University

Introduction

This study is a part of a master's thesis which is to create and evaluate applications (mobile app and stop) for public transportation (i.e., bus). The purpose of this study is to evaluate the interfaces by task analysis and Nielson's heuristics.

Please keep in mind that there are no right or wrong answers. Each participant plays a fundamental role in the improvement of these two applications, with the intention to create positive user experiences. The task analysis is consisted of 8 tasks of which 6 for the mobile application and 2 for the bus stop application. At the end of the task analysis, you are asked to do Nielson's Heuristics to reveal how usability is succeeding or failing on the current project.

Test goals

This test aims to evaluate the layout of the two platforms present according to Nielsen's heuristics.

Procedure

The test is divided into 3 steps:

1 – Understand the objective of the study;

2 – Do the Task Analysis;

3 – 10 Nielson’s Heuristics.

Scenario

Imagine that you will not have to go to either kiosks or the ATM to be able to recharge your pass, you can do it using your mobile phone. You can also check if you need to recharge your pass. When you arrive at the bus stop you can book your seat in the bus and check in real time where the bus is.

Task Analysis

For the application for the mobile phone 8 tasks are given as follows:

Task 1: Register

This is the first time that you will interact with this application, please register yourself.

Task 2: Go home

You are at the restaurant. You finished your meal and you want to go home by bus, go home by bus 714.

Task 3: Add to favorites

You often go to IADE, add IADE to your favorites.

Task 4: Check your pass

You don't remember when you last charged your pass, check how much time is left to recharge it.

Task 5: Recharge your pass

You have to charge your pass, please recharge the pass with the mastercard card.

Task 6: Schedule your journey

You have a meeting at 18h at Vasco da Gama. Schedule your trip by choosing the 755 bus.

For the bus stop application, it is only one task:

Task 1: Choice of the bus

You will have an appointment at the hospital in Olivais, choose Olivais as a stop and as you are in a hurry, choose the bus that arrives the fastest.

Task 2: Pay the bus

Pay the trip with your pass, since it's charged.

Criteria measurements

In the table will be a part where you should rate the severity of the violated heuristic using the scale above:

0 = I don't agree that this is a usability problem at all
1 = Cosmetic problem only: need not be fixed unless extra time is available on project
2 = Minor usability problem: fixing this should be given low priority
3 = Major usability problem: important to fix, so should be given high priority
4 = Usability catastrophe: imperative to fix this before product can be released

Problem category

You should categorize the problems found into 6 categories:

- Visual hierarchy (conducts the viewers looks first to the primary content and then to the secondary content);
- Terminology (if the terms and vocabulary is adequate to the user);
- Interaction (a failure in the interaction between user and platform);
- Labeling (missing labeling in the layouts);
- Feedback (lack of feedback given to the users by the platforms);
- Visual consistency. (lack of visual consistency in the layouts such as graphics, color schemes, fonts, logo, etc)

Usability heuristics

Jacob Nielsen's 10 usability heuristics:

H1 – Visibility of system status: Feedback given to the user when he/she interacts with the system

H2 – Match between system and the real world: Usage appropriate language, icons and images that users can recognize from the real world.

H3 – User control and Freedom: Having a clear exit to unwanted actions performed by the users.

H4 – Consistency and Standards: Respect the platform conventions.

H5 – Error prevention: Prevention of errors.

H6 – Recognition rather than Recall: Make elements, actions and options more visible.

H7 – Flexibility and Efficiency of Use: Have shortcuts for expert users.

H8 – Aesthetic and Minimalist Design: Cut the extra irrelevant information.

H9 – Recognize, Diagnose and Recover from Errors: Errors should be explained in a plain user understanding way.

H10 – Help and Documentation: It's best when the design doesn't need any extra information.

Heuristic table evaluation for the smartphone app

Name:
Date:
Platform (bus or bus stop):

Link to the smartphone app prototype:
https://xd.adobe.com/view/bffaa5a0-0801-41fb-b71f-2d9fbfdfb354-eaa9/?fullscreen&hints=off

Task	Violated Heuristic	Severity Criteria	Problem category	Problem Found	Suggested Improvements	Screenshot

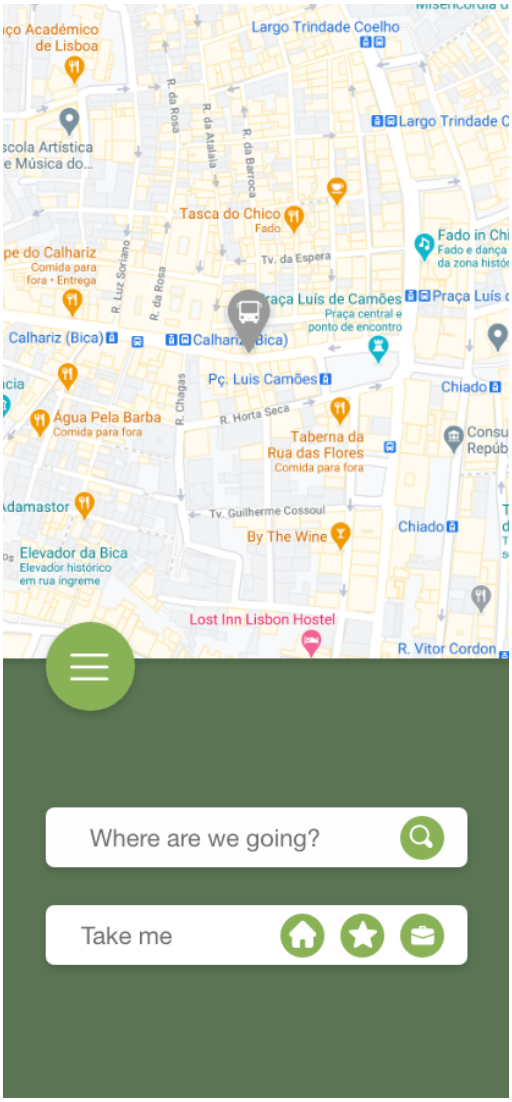
Heuristic table evaluation for the bus stop platform

Name:
Date:
Platform (bus or bus stop):

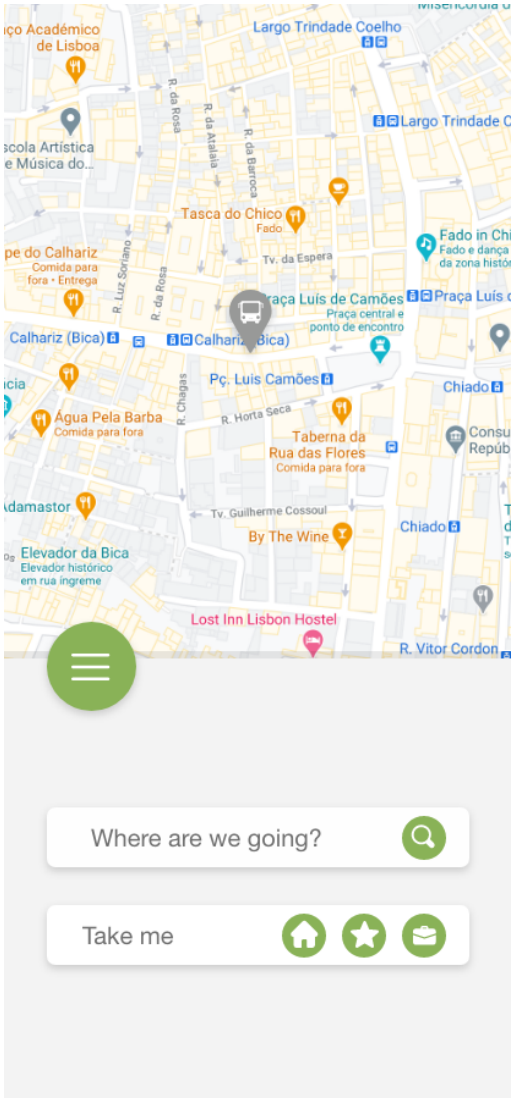
Link to the bus stop platform prototype:
https://xd.adobe.com/view/ff5fcf1a-5f60-4035-8d38-f8db5c4a165c-aa0c/?fullscreen&hints=off

Task	Violated Heuristic	Severity Criteria	Problem category	Problem Found	Suggested Improvements	Screenshot

Which Layout do you prefer?



Layout 1

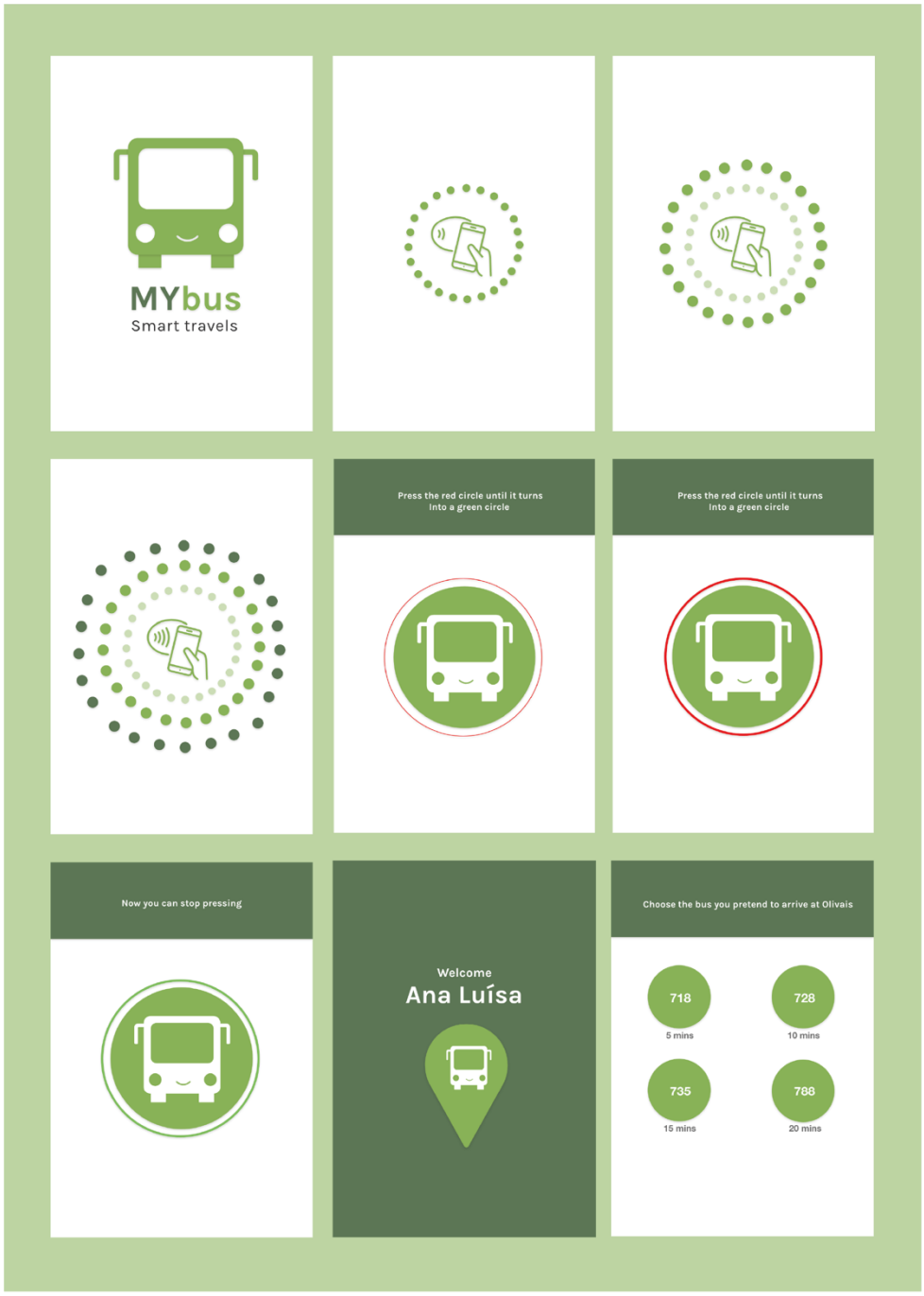


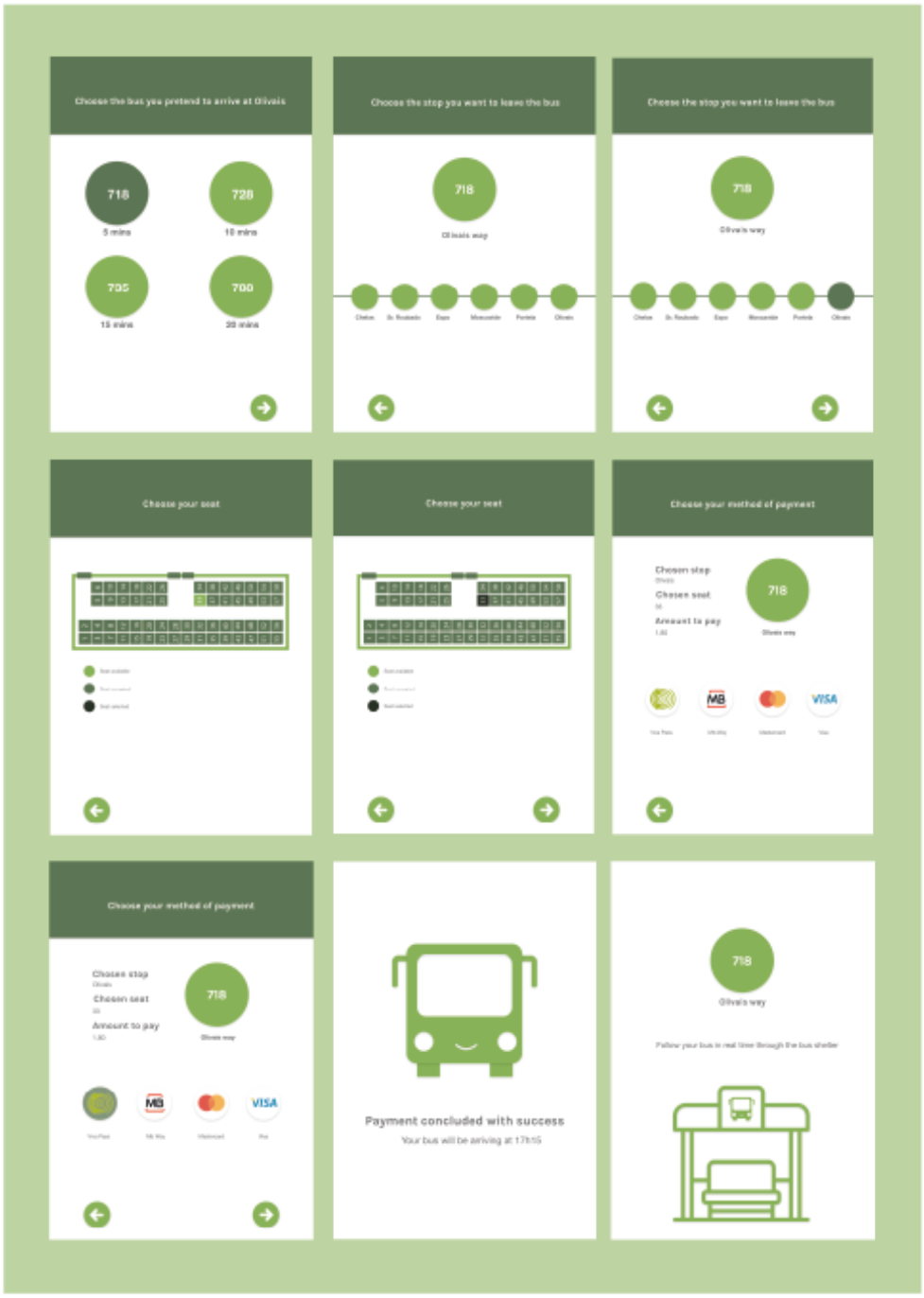
Layout 2

Thank you for your time!

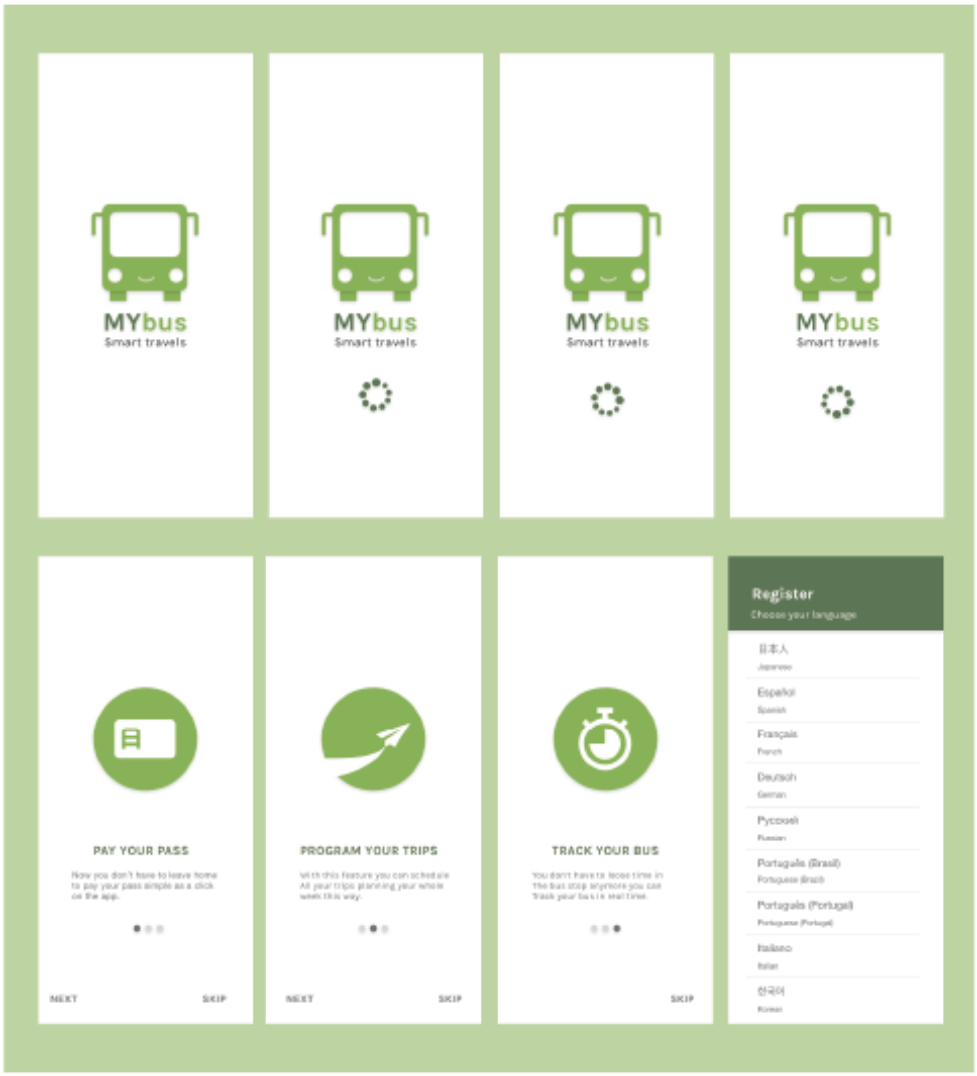
J. Final Interfaces

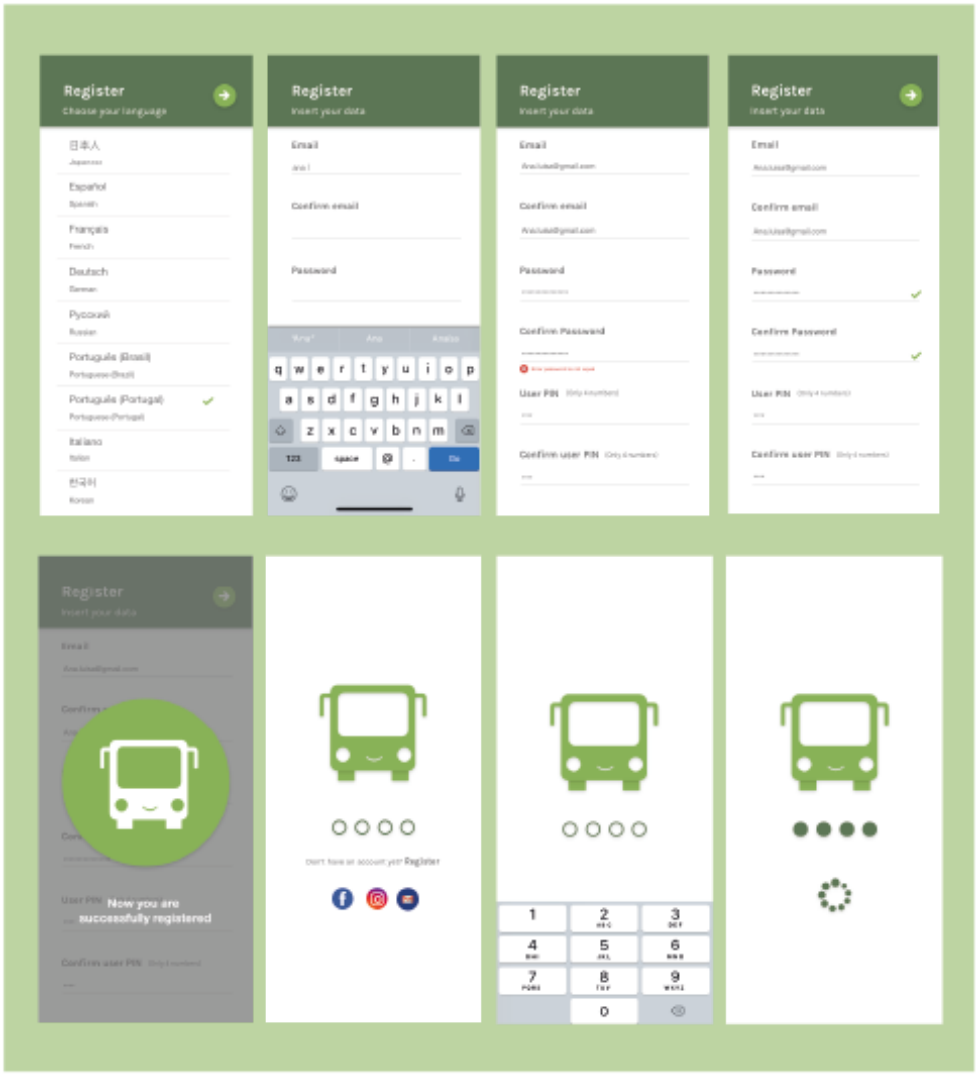
J.1. Bus Platform Final Interfaces

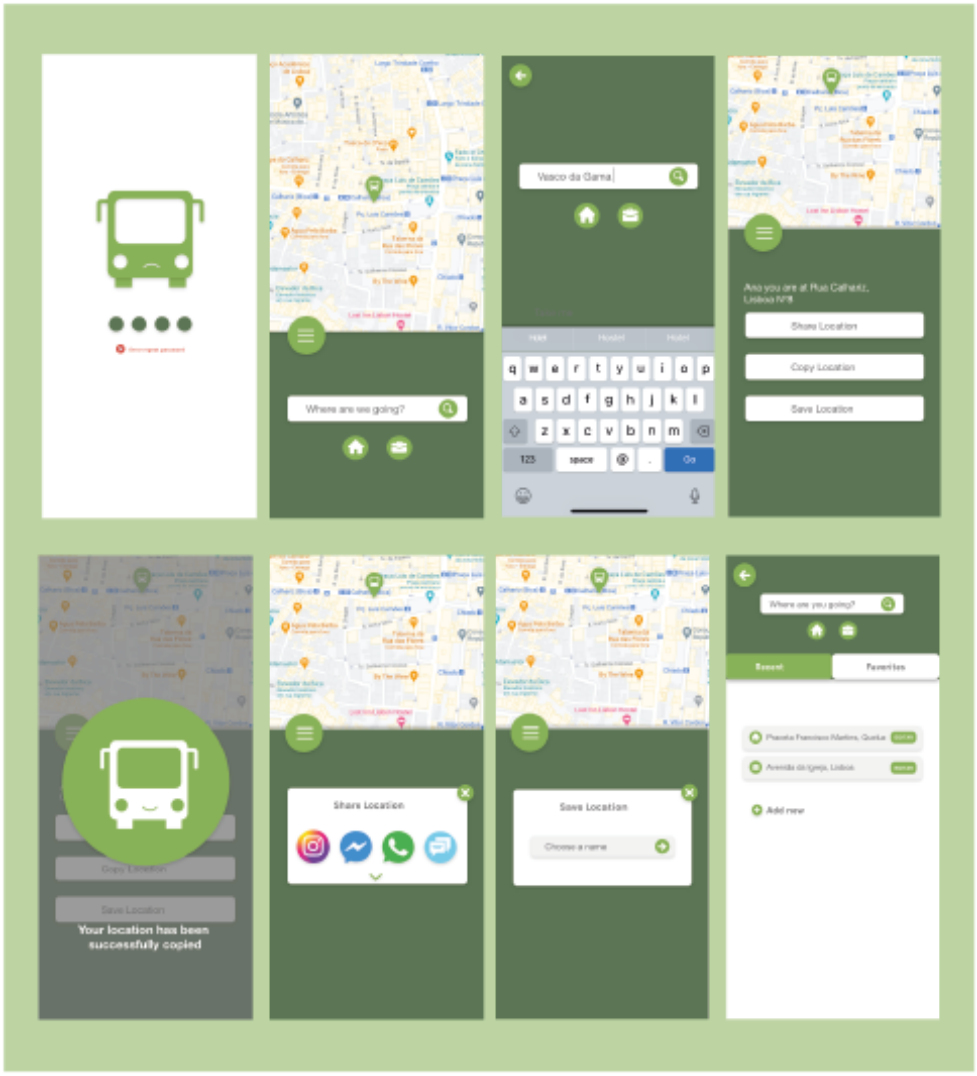



Choose the bus you pretend to arrive at Oliveis
718
5 mins
728
15 mins
705
15 mins
700
20 mins
Choose the stop you want to leave the bus
718
Choose the stop you want to leave the bus
718
Choose your seat
Choose your seat
Choose your method of payment
Chosen stop
Chosen seat
Amount to pay
718
Choose your method of payment
Chosen stop
Chosen seat
Amount to pay
718
VISA
Payment concluded with success
Your bus will be arriving at 17h15
718

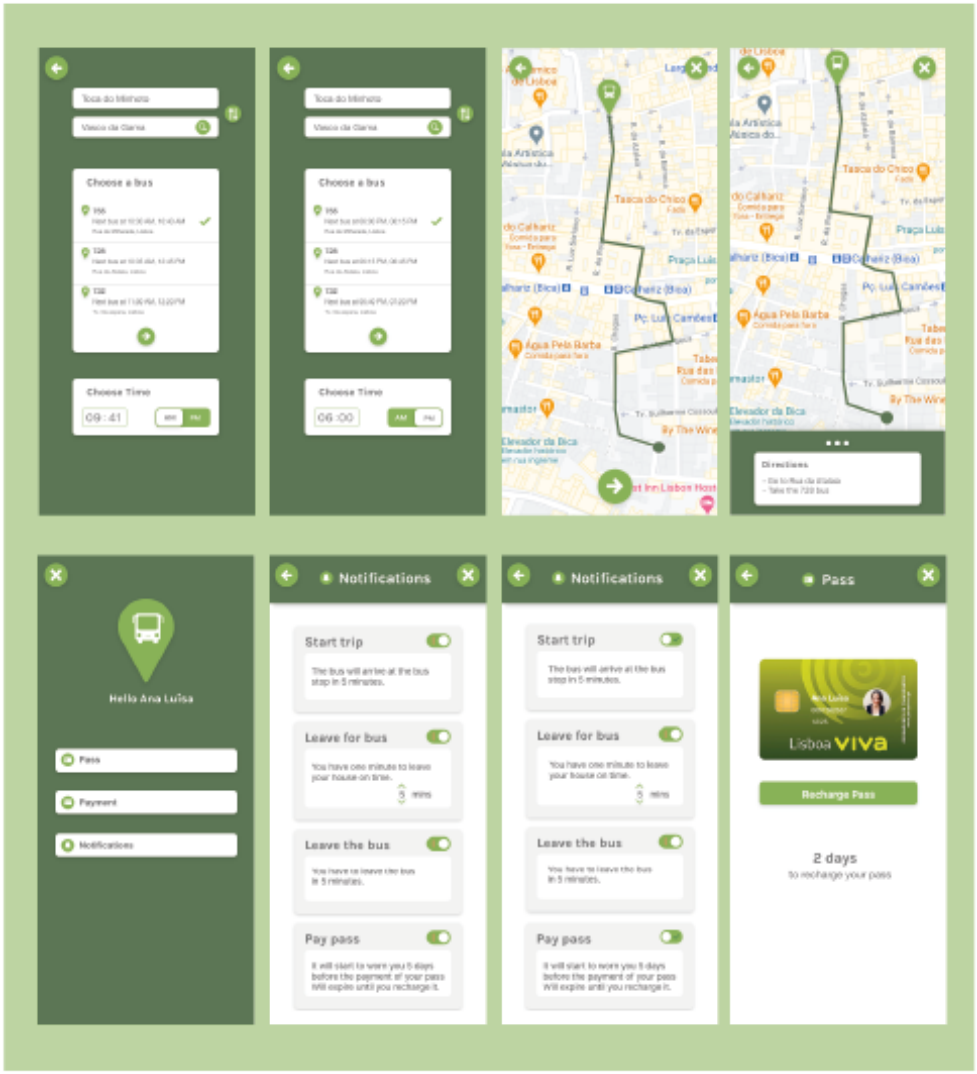
J.2. Smartphone App Final Interfaces

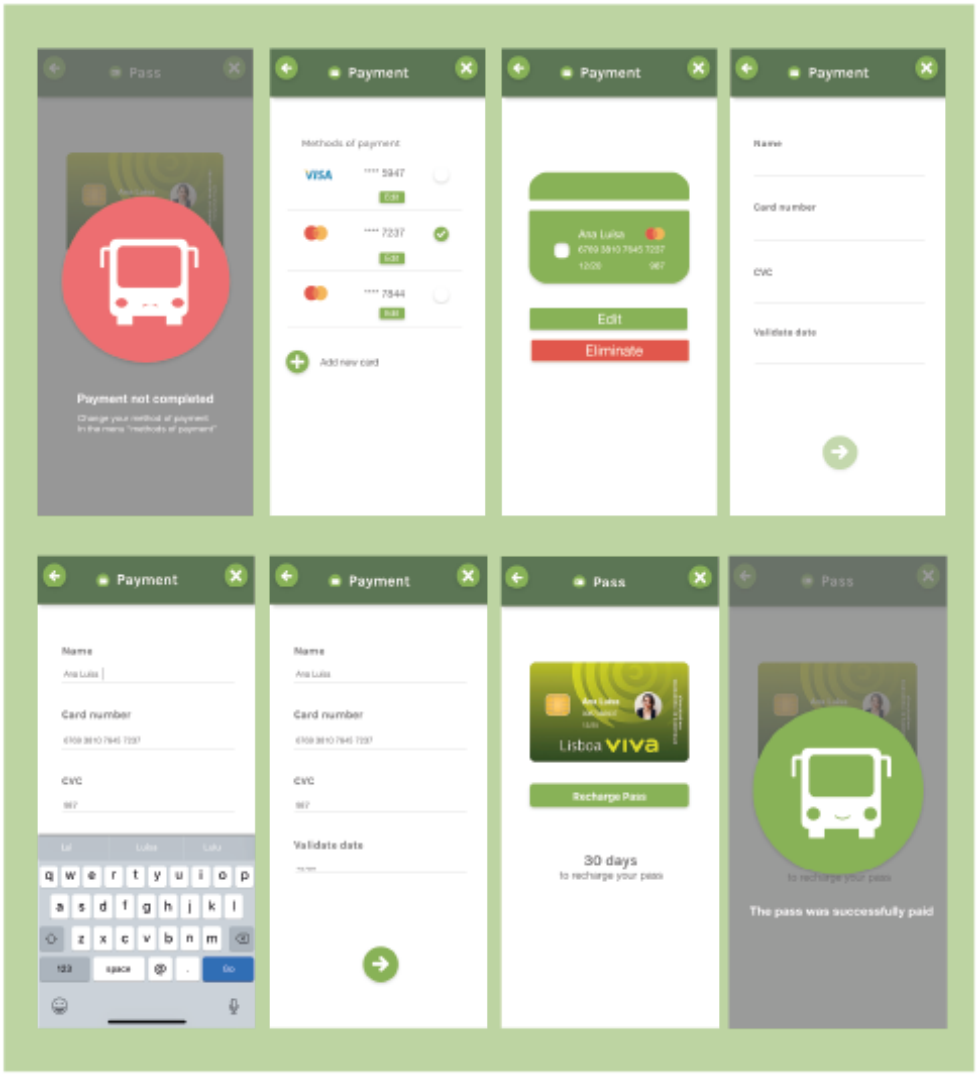



Register
Register
Register
Register
Register
Now you are successfully registered


Where are we going?
Share Location
Copy Location
Save Location
Your location has been successfully copied
Share Location
Save Location
Choose a name
Where are you going?
Recent
Favorites
Add new


Add new
Search
Examples
Choose a name
Where are you going?
Recent
Favorites
Praça do Rossio
Praça de Moscavide
Centro Comercial do Colombo
Vasco da Gama
Choose a bus
Choose Time


Choose a bus
Choose Time
Hello Ana Luísa
Pass
Payment
Notifications
Notifications
Start trip
Leave for bus
Leave the bus
Pay pass
Notifications
Start trip
Leave for bus
Leave the bus
Pay pass
Pass
Lisboa viva
Recharge Pass
2 days


Pass
Payment not completed
Payment
Methods of payment
VISA
Add new card
Payment
Ana Luísa
Edit
Eliminate
Payment
Name
Card number
CVC
Validate date
Payment
Name
Ana Luísa
Card number
CVC
Payment
Name
Ana Luísa
Card number
CVC
Validate date
Pass
Lisboa viva
Recharge Pass
30 days
to recharge your pass
Pass
The pass was successfully paid